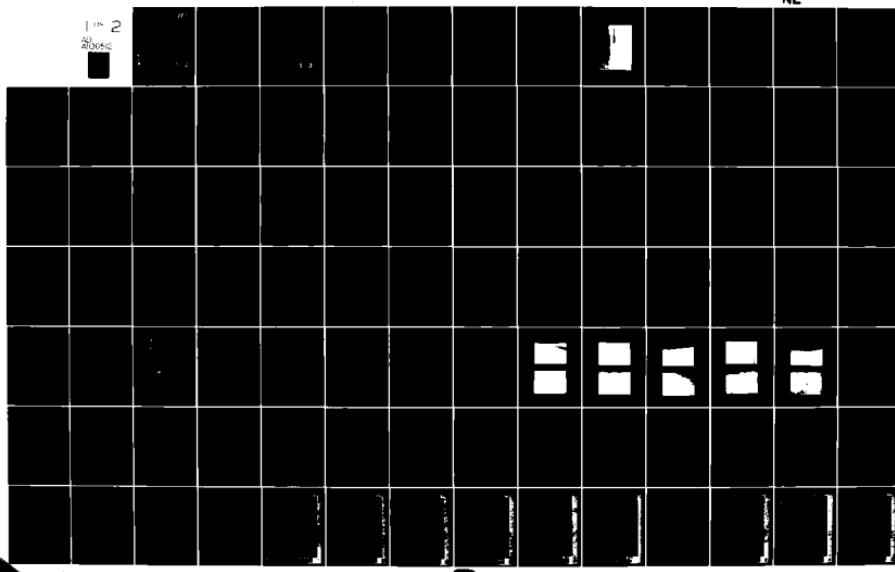


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NATIONAL DAM SAFETY PROGRAM, WESTHOFF DAM (MO 11140), MISSISSIPPI--ETC(U)
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WESTHOFF DAM
LINCOLN COUNTY, MISSOURI
MO. 65440

PHASE I INSPECTION REPORT NATIONAL DAM SAFETY PROGRAM

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DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT CORPS OF ENGINEERS
210 TUCKER BOULEVARD NORTH
ST. LOUIS MISSOURI 63114

REPLY TO
ATTENTION:

SUBJECT: Westhoff Dam (Mo. 11140) Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Westhoff Dam (Mo. 11140).

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, non-emergency by the St. Louis District as a result of the application of the following criteria:

- 1) Spillway will not pass 50 percent of the Probable Maximum Flood
- 2) Overtopping could result in dam failure
- 3) Dam failure significantly increases the hazard to loss of life downstream

SIGNED

2 OCT 1980

SUBMITTED BY:

Chief, Engineering Division

Date

SIGNED

APPROVED BY:

Colonel, CE, District Engineer

Date

6 OCT 1980

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WESTHOFF DAM
LINCOLN COUNTY, MISSOURI

MISSOURI INVENTORY NO. 11140

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

PREPARED BY
CONSOER, TOWNSEND AND ASSOCIATES, LTD.
ST. LOUIS, MISSOURI
AND
PRC ENGINEERING CONSULTANTS, INC.
ENGLEWOOD, COLORADO
A JOINT VENTURE

UNDER DIRECTION OF
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
FOR
GOVERNOR OF MISSOURI

SEPTEMBER 1980

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam: Westhoff Dam, Missouri Inv. No. 11140
State Located: Missouri
County Located: Lincoln
Stream: An unnamed tributary of Bobs Creek
Date of Inspection: April 21, 1980

Assessment of General Condition

Westhoff Dam was inspected by the engineering firms of Consoer, Townsend and Associates, Ltd. and PRC Engineering Consultants, Inc. (A Joint Venture) of St. Louis, Missouri according to the U. S. Army Corps of Engineers "Engineer Regulation No. 1110-2-106" and additional guidelines furnished by the St. Louis District of the Corps of Engineers. Based upon the criteria in the guidelines, the dam is in the high hazard potential classification, which means that urban development with more than a small number of habitable structures could be affected in the event of failure of the dam. Within the estimated damage zone of one mile downstream of the dam are four dwellings, four buildings, three trailers, one gas station, and a pond which may be subjected to flooding, with possible damage and/or destruction, and possible loss of life. Westhoff Dam is in the small size classification since it is 25 feet high, and impounds more than 50 acre-feet but less than 1,000 acre-feet of water.

The overall condition of the dam and appurtenant structures appears to be satisfactory, however, the dam does not have adequate spillway capacity. Our inspection and evaluation indicates that the spillway of Westhoff Dam does not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. Westhoff Dam, being a small size dam with a high hazard potential, is required by the guidelines to pass from one-half of the Probable Maximum Flood to the Probable Maximum Flood without overtopping. Considering the volume of water impounded, the relatively narrow valley and the number of dwellings downstream of the dam, the PMF is considered the appropriate spillway design flood for this dam. It was determined that the reservoir/spillway system can accommodate approximately 20 percent of the Probable Maximum Flood without overtopping "effective top of the dam". The "effective top of the dam" is defined as the lake elevation at which corresponding outflow velocity exceeds suggested maximum permissible mean velocity in the emergency spillway channel. Our evaluation indicates that the reservoir/spillway system can accommodate the one-percent chance flood (100-year flood) without overtopping the "effective top of the dam".

The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorological and hydrologic conditions that are reasonably possible in the region.

Other deficiencies noted by the inspection team were: livestock activities on the embankment, the erosion gullies on the left abutment and upstream of the emergency spillway, minor wave erosion on the upstream slope, small saplings on the upstream slope, damage of protective grass cover on the emergency spillway by vehicular traffic, damage of downstream slope area surrounding the principal spillway outlet pipe by cattle, minor obstructions in the emergency spillway approach area, a need for periodic inspec-

tion by a qualified engineer and a lack of maintenance schedule. The lack of seepage and stability analyses on record is also a deficiency that should be corrected.

It is recommended that the owner take action to correct or control the deficiencies described above.



Walter G. Shifrin, P.E.



Overview of Westhoff Lake Dam



NATIONAL DAM SAFETY PROGRAM

WESTHOFF DAM, I.D. No. 11140

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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

WESTHOFF DAM, Missouri Inv. No. 11140

SECTION I: PROJECT INFORMATION

1.1 General

a. Authority

The Dam Inspection Act, Public Law 92-367 of August, 1972, authorizes the Secretary of the Army, through the Corps of Engineers, to initiate a national program of dam inspections. Inspection for Westhoff Dam was carried out under Contract DACW 43-80-C-0094 between the Department of the Army, St. Louis District, Corps of Engineers, and the engineering firms of Consoer, Townsend & Associates, Ltd., and PRC Engineering Consultants, Inc. (A Joint Venture), of St. Louis, Missouri.

b. Purpose of Inspection

The visual inspection of Westhoff Dam was made on April 21, 1980. The purpose of the inspection was to make a general assessment as to the structural integrity and operational adequacy of the dam embankment and its appurtenant structures.

c. Scope of Report

This report summarizes available pertinent data relating to the project, presents a summary of visual observations made during the field inspection, presents an assessment of hydrologic and hydraulic conditions at the site, presents an assessment of the structural adequacy of the various project features and assesses the general condition of the dam with respect to safety.

Subsurface investigations, laboratory testing and detailed analyses were not within the scope of this study. No warranty as to the absolute safety of the project features is implied by the conclusions presented in this report.

It should be noted that in this report reference to left or right abutments is viewed as looking downstream. Where left abutment or left side of the dam is used in this report, this also refers to the west abutment or side, and right to the east abutment or side.

d. Evaluation Criteria

The inspection and evaluation of the dam is performed in accordance with the U.S. Army Corps of Engineers "Engineer Regulation No. 1110-2-106" and additional guidelines furnished by the St. Louis District office of the Corps of Engineers for Phase I Dam Inspection.

1.2 Description of the Project

a. Description of Dam and Appurtenances

The following description is based exclusively upon observations and measurements made during the visual inspection and from a conversation made with Mr. Leonard Westhoff, Jr., the owner. Original SCS design drawings and some computation sheets were located and are presented in this report, however, most of the dimensions on the design drawings do not correspond with the field measurements.

The dam is a homogeneous, rolled earthfill structure with a straight alignment between earthen abutments. The crest width of the embankment is 16 feet and the crest has a total length of 730 feet (excluding the top width of the emergency spillway). According to the drawings, the crest was supposed to be 10 feet wide and no crest length was given. The crest elevation is at approximately 470 feet above mean sea level (MSL). The maximum height of the embankment is 25 feet. The upstream and downstream slopes were measured to be 1 vertical to 3 horizontal (1V to 3H) and 1V to 2.25H, respectively. According to the drawings, the upstream and downstream slopes were to be 1V to 3H and 1V to 2H, respectively.

According to Mr. Westhoff, a trapezoidal shaped core trench was excavated parallel to the dam axis. The trench was not excavated to bedrock. The compaction of the embankment was achieved only by the earthmoving equipment used for the placement of the fill. No compaction control tests were performed. The materials used for the embankment were removed from the reservoir.

There were two spillways designed for the dam, a principal spillway and an emergency spillway. The principal spillway is an 18-inch diameter (17.5-inch I.D.) welded steel pipe, laid through the fill approximately 310 feet from the left abutment, with two steel antiseep collars welded to it; one is located at 25 feet and the other at 50 feet from the inlet. The antiseep collars are 6-foot square plates and are not founded on bedrock. A segmentally shaped endplate, approximately 3.5 inches in its maximum rise is welded to the opening at the top of the pipe at the inlet end; from the straight edge of the endplate, the pipe itself has been cut back on a 45 degree angle from the plane of the pipe opening. This constitutes the inlet of the principal spillway. The 104-foot long spillway conduit falls 8.23 feet from inlet end to outlet end; the inlet invert elevation is 456.8 and the outlet invert elevation is 448.57. The outlet end condition allows flows to fall approximately 20 inches to a pool area slightly wider than the downstream channel. The emergency spillway was cut into the top of the dam at the right abutment area with a measured 58 foot top width and an approximately 30 foot bottom width at the control section. The channel is 3 feet deep and has a side slope of from 1V to 3-1/3H on the right side and 1V to 5-1/3H on the left side. The channel then widens and follows along the toe of the dam and outlets at the same point as the principal spillway, joining the downstream channel perpendicularly at this point. The channel invert and sides have a dense grass cover protection.

There were no regulated outlet works or low-level drains provided for this dam.

b. Location

Westhoff Dam is located in the state of Missouri, Lincoln County, across an unnamed tributary to Bobs Creek which is tributary to the Mississippi River. It can be found on the 7.5 minute series of the Winfield, Mo.-Ill. Quadrangle, in survey No. 816, Range 2E, Township 49N.

c. Size Classification

According to the "Recommended Guidelines for Safety Inspection of Dams", by the U.S. Department of the Army, Office of the Chief Engineer, the dam is classified in the dam size category as being "small" since its storage is less than 1,000 acre-feet and more than 50 acre-feet. The dam is also classified as "small" in dam size category because its height is 25 feet. The overall size classification is, accordingly, "small".

d. Hazard Classification

The dam has been classified as having a "high" hazard potential in the National Inventory of Dams, on the basis that in the event of failure of the dam or its appurtenances, excessive damage could occur to urban development with more than a small number of habitable structures, together with the possibility of the loss of life. Our findings concur with this classification. Within the estimated damage zone which extends approximately one mile downstream from the dam, are four dwellings, one pond, three trailers, a gas station, and four buildings.

e. Ownership

Westhoff Dam is owned privately by Mr. and Mrs. Leonard Westhoff, Jr. and Mr. Eugene Franke. Mr. and Mrs. Westhoff, Jr. own the crest, upstream slope and spillway sections of the dam and Mr. Franke owns the downstream slope. The mailing addresses are Mr. and Mrs. Leonard Westhoff, Jr., R.R. 2, Box 248, Winfield, Missouri, 63389, and Mr. Eugene Franke, R.R. 2, Box 250, Winfield, Missouri, 63389.

f. Purpose of Dam

The main purposes of the dam are flood control and to retain soil that is eroded from the watershed upstream of the dam.

g. Design and Construction History

Westhoff Dam was designed by the Department of Agriculture, Soil Conservation Service, Troy, Missouri office. Mr. Jack Angle was the soil conservationist for the project. The dam was built in December, 1974 by G & P Ditching Service, Inc., O'Fallon, Missouri.

Mr. Charles Grabenhorst, who is with G & P Ditching Service, Inc., stated that the dam had an adequate core trench which extended into solid clay material. The dam was built according to Soil Conservation Service standards and specifications. Mr. Angle periodically inspected the construction of the dam.

h. Normal Operational Procedures

There is no operational procedure which is followed for the operation of Westhoff Dam Reservoir. Normally, the water level in the reservoir is controlled by rainfall, runoff, evaporation, and the crest elevation of the principal spillway. This is the normal procedure for operation of the reservoir.

1.3 Pertinent Data

a. Drainage Area (square miles): 0.58

b. Discharge at Damsite

Estimated experienced maximum flood (cfs): 350

Estimated ungated spillway capacity with reservoir at top of dam elevation (cfs): 902

c. Elevation (Feet above MSL)

Spillway crest:

d. Reservoir

Length of pool at top of dam elevation (Feet): 1400

e. Storage (Acre-Feet)

Spillway crest:

f. Reservoir Surfaces (Acres)

Spillway crest:

Principal Spillway	1.9
Emergency Spillway	10.5
Normal Pool:	1.9
Maximum Experienced Pool:	14-
Observed Pool:	2

g. Dam

Type:	Rolled, Earthfill
Crest Length:	730 feet
Structural Height:	25 feet
Hydraulic Height:	25 feet
Crest width:	16 feet
Embankment slopes:	
Downstream	1V to 2.25H (measured)
Upstream	1V to 3H from crest to waterline, remainder unknown
Zoning:	Unknown
Impervious core:	None according to design drawing
Cutoff:	None
Grout curtain:	None

h. Diversion and Regulating Tunnel None

i. Spillway

Type:	
Principal Spillway	17.5-inch I.D. steel pipe, uncontrolled
Emergency Spillway	Open channel, uncontrolled
Length of crest:	
Principal Spillway	17.5-inch I.D. steel pipe
Emergency Spillway	32 feet (bottom width of the trapezoidal channel)
Crest Elevation (feet above MSL):	

Principal Spillway 456.8

Emergency Spillway 467

j. Regulating Outlets None

SECTION 2: ENGINEERING DATA

2.1 Design

Design sketches are available from the Department of Agriculture, Soil Conservation Service, and are included as part of this report. The sketches were prepared in June of 1974 by the Department of Agriculture, Soil Conservation Service.

The dam was designed on the basis of Soil Conservation Service Standard and Specifications for Ponds (Bulletin 378). Engineering computations for this project were also available and are included in this report.

2.2 Construction

No data are available concerning the construction of the dam and appurtenant structures, other than the construction history given in Section 1.2a and Section 1.2g

2.3 Operation

No operation records are available for Westhoff Dam.

2.4 Evaluation

a. Availability

The availability of engineering data is fair and consists of the design sketches, engineering computations, State Geological Maps and U.S.G.S. Quadrangle Sheets. No data were available with regard to subsurface investigations or soil testing for the dam.

b. Adequacy

The conclusions presented in this report are based on field measurements, the available engineering data, past performance and present condition of the dam. The available data and the field measurements are adequate to evaluate the hydraulic and hydrologic capabilities of the dam. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions and made a matter of record.

c. Validity

Design sketches and computations were available for review. From field measurements, the dam appears to have been constructed according to the available sketches, except for the discrepancies described in Section 1.2a.

SECTION 3: VISUAL INSPECTION

3.1 Findings

a. General

A visual inspection of the Westhoff Dam was made on April 21, 1980. The following persons were present during the inspection:

Name	Affiliation	Disciplines
Dr. M.A. Samad	PRC Engineering Consultants, Inc.	Project Engineer, Hydraulics and Hydrology
Mark R. Haynes	PRC Engineering Consultants, Inc.	Soils and Mechanical
Robert McLaughlin	PRC Engineering Consultants, Inc.	Civil
Razi Quraishi	PRC Engineering Consultants, Inc.	Geology
John Lauth	Consoer, Townsend & Assoc., Ltd.	Civil and Structural
Mr. Leonard Westhoff, Jr.	One of the Owners	

Specific observations are discussed below.

b. Dam

The crest of the dam is adequately protected against surface erosion by a good vegetative cover. The crest is used occasionally as a farm road. Consequently, a few small ruts have been formed. There was no evidence of significant settlement or cracking on the crest. No significant deviations in horizontal or vertical alignment were apparent. According to Mr. Westhoff, the dam has never been overtopped and no evidence indicating the contrary was observed.

The upstream slope has no riprap protection, consequently, some minor erosion, due to wave action, has occurred near the water surface. The portion of the slope above the water surface is adequately protected from surface erosion by a good vegetative cover. The slope showed signs of grazing livestock activity. There were some very small shallow surface sloughs along the slope and a few small U-shaped scarps near the water surface. One erosion gully was observed near the center of the emergency spillway extending from the crest of the spillway down the slope to near the water surface. The gully was approximately 2 feet wide and 1 foot deep. Some small saplings were observed along the shoreline and around the intake to the service spillway. No depressions, cracks or settlements were apparent on the slope. According to the available drawings, a bench was to be constructed at the elevation of the principal spillway inlet. The bench, however, was not observed.

The downstream slope from the right abutment to just left of the principal spillway appeared to be used to pasture livestock and the other portion of the embankment slope appeared to be used for some other agricultural activity. The right side of the slope appeared to be damaged by grazing livestock similarly to the upstream slope. There were some very small shallow surface sloughs along the slope and one cattle trail. The cattle trail extended along the entire portion of the slope and was located approximately 3 feet below the crest. The slope around the principal spillway appeared to have been slightly steepened due to the grazing livestock. The entire slope appeared to have an adequate vegetative cover to protect it from surface erosion. No bulges, depressions, cracks or settlements were apparent on the slope. No seepage was apparent along the toe of the slope.

Both abutments slope gently upward from the crest of the dam. No erosion or instabilities were observed on the right abutment. An erosion gully was observed just upstream of the embankment/abutment contact on the left abutment. No instabilities were apparent on the left abutment. No seepage was observed on either abutment.

No rodent activity was apparent on the embankment or abutments.

c. Project Geology and Soils

(1) Project Geology

The damsite is located on the unnamed tributary of Bobs Creek in the Springfield Plateau section of the Ozark Plateaus Physiographic Province. The Springfield Plateau includes that part of the Ozarks which is underlain mainly by

the rocks of Mississippian age. Most of the Springfield Plateaus are prairies which are separated by valleys cut 200 feet to 300 feet below the upland surface. Most of the area of the Springfield Plateaus is overlain by a mantle of chert released by weathering of the Mississippian Limestone. The topography of the damsite area is rolling with U-shaped valleys. Elevation ranges from 500 feet above M.S.L. (nearly 0.25 miles west of the damsite) to 470 feet M.S.L. at the Westhoff Lake Dam. The reservoir slopes are 5° to 18° from horizontal. The reservoir appears to be water tight. A slight to moderate localized erosional gully activity was observed at the northeastern portion of the reservoir rim. This localized gully erosion appears to be not a detriment to the stability of the reservoir bank.

The area at the damsite is covered with a mixture of slope wash deposits of glacial-fluvial origin and loess consisting of yellowish-brown sandy silt origin. No outcropping of bedrocks was seen at the damsite.

The inlet and outlet areas of the unnamed tributary of Bobs Creek contain Quaternary alluvium. The areal bedrock geology beneath the slope wash deposits as shown on the Geologic Map of Missouri (1979), Plate 9, consists of Pennsylvanian rocks of the Cherokee Group (cyclic deposits of shales, limestone, and sandstone) and Mississippian limestones of the Salem and St. Louis Formations.

No faults have been identified at the vicinity of the damsite. The closest trace of a fault to the damsite is the Cap Au Gres faulted flexure nearly 5 miles north of the site. The Cap Au Gres faulted flexure had its last movement in post-Pennsylvanian, pre-Pleistocene time. This fault appears to have no effect on the dam.

Westhoff Lake Dam consists of a homogeneous earth-fill embankment, a principal spillway metal pipe located at the mid-section of the embankment and an emergency spillway is located at the right abutment end of the embankment.

No boring logs or construction reports were available which could indicate foundation conditions encountered during dam construction. Based upon the visual inspection and from the personal communication with the owner, Mr. Westhoff, the embankment probably rests on glacial deposits of yellowish-brown clayey silt and some fine to medium sand. The foundation material underneath the principal spillway metal pipe is compacted embankment fill (yellowish-brown silty clay). The emergency spillway was cut into the compacted embankment fill.

(2) Project Soils

According to the "Missouri General Soil Map and Soil Association Descriptions" published by the Soil Conservation Service, the materials in the general area of the dam belong to the soil series of Menfro-Winfield-Lindley in the central Mississippi Valley wooded slopes family. The soils were basically formed from loess and glacial till. The permeability of these soils range from moderate to moderately slow. The Lindley soil is generally quite susceptible to erosion. If the Lindley soil type was used in the embankment, the potential of failure of the embankment would be increased due to erosion during overtopping.

Materials removed from the embankment on the upstream and downstream slopes approximately one foot below the vegetative cover appeared to be a yellowish-brown silty clay. Based upon the Unified Soil Classification System, the

soil would probably be classified as a CL. This soil type generally has the following characteristics: impervious with a coefficient of permeability less than 1.0 foot per year; medium shear strength; and a high resistance to piping.

d. Appurtenant Structures

(1) Principal Spillway

The principal spillway conduit has been in place for five years and appears to be in good condition. Judging from the exposed ends of the pipe, it would appear that the entire length was protected with an asphaltic covering. The inlet end has some exposed areas of the pipe unprotected which have a light coating of rust; the outlet end also has approximately one to two feet of unprotected and rusted conduit. There is a small growth of bush type plants adjacent to the inlet where dead grass, etc., is able to collect and the inlet itself is set back into the upstream slope forming a gradual approachway; since there is no headwall-wingwall construction it is possible for moss and other floating debris to be carried by the current around the approachway and collect at the inlet opening. The edge of the downstream slope in the vicinity of the principal spillway outlet has no rock or grass protection. The area has been trampled and eroded due to livestock watering and wave action.

(2) Emergency Spillway

The emergency spillway crest is three feet lower than the top of dam and is constructed into the right end of the embankment. The centerline of the spillway channel is perpendicular to the axis of the dam at the inlet, but curves around the downstream slope of the dam and follows the embank-

ment until it intersects with the principal spillway outlet. In fact, the downstream slope and the left channel side slope merge and function as one. The channel invert and side slopes seem to have adequate grass cover protection; however, at the inlet there appears to be a soft spot where vehicular tires have rutted, and grass coverage is sparse. The emergency spillway was used during a storm in 1975 and approximately two feet of water was carried over the crest, according to the owner. No damage, cracks, bulges or settlements, or misalignments were observed. Some minor erosion was observed at the downstream end of the channel, it takes the form of gulleys and occurs at the point where the slope steepens just before the entrance to the principal spillway outlet pool area.

(3) Outlet Works

There were no regulated outlet works or low level drain pipes constructed for this dam. Although there is no low-level drain system, the freeboard above normal reservoir level is greater than 10 feet.

e. Reservoir Area

The water level for the reservoir was at elevation 457.0 feet above M.S.L. on the day of inspection.

The reservoir rim is sloped gently and no indication of instability or severe erosion was readily apparent. The slopes surrounding the reservoir are gentle and partially tree-covered and partially in agriculture. There are no homes or other structures built near the reservoir.

f. Downstream Channel

The downstream channel is a well defined meandering channel. The channel has a bottom width of about five feet and a side slope of 1V to 3H on both sides. The channel is approximately eight feet deep. Some trees were observed growing in the channel. The trees could affect the hydraulic efficiency of the channel.

3.2 Evaluation

The visual inspection revealed nothing of a sufficiently significant nature to require immediate remedial action. However, the following conditions were observed during the visual inspection which could cause adverse effects on the dam in the future.

1. The damage to the upstream and downstream slopes due to the grazing livestock, could affect the stability and safety of the dam, if the livestock activity is allowed to continue.

2. The erosion on the left abutment and upstream of the emergency spillway pose potential danger to the stability of the embankment.

3. The small saplings on the upstream slope do not pose a danger to the safety of the dam at this time. Nevertheless, if the saplings are allowed to grow, they could pose a potential danger to the safety of the dam. Depending upon the extent of the root systems of large trees, the roots could provide paths for piping through the embankment.

4. The minor wave erosion on the upstream slope, if allowed to continue, could affect the structural stability of the dam.

5. The vehicular path worn into the crest of the emergency spillway is in a potentially soft area; since the crest has been rutted and the protective grass cover has been worn away, this area could be severely damaged by the erosive effects of floodwaters passing over the crest.

6. The downstream slope area surrounding the principal spillway outlet pipe has been trampled by cattle maneuvering for drinking water thus destroying the protective grass cover and opening a large area to the erosive effects of rains. Potentially serious problems and local instability could result from this area.

7. The gathering of floating moss, dead grass, and small sapling or bush type plants near the principal spillway inlet approachway could easily result in an inefficient functioning of the spillway.

SECTION 4: OPERATIONAL PROCEDURES

4.1 Procedures

Westhoff Dam is used to impound water from rainfall and runoff for flood control and soil conservation. There are no specific procedures which are followed for the operation of the dam. The water level in the reservoir is controlled by rainfall, runoff, evaporation and by the elevation of the crest of the principal spillway. There are no staff gages or monitoring devices to check the water level.

4.2 Maintenance of Dam

The dam is maintained by the owner, Mr. Leonard Westhoff, Jr. The slopes and the dam crest are mowed periodically. However, a few small trees have started to grow near the principal spillway pipe on the upstream side of the dam.

There are erosion gullies forming at the left abutment contact on the upstream side and at the emergency spillway inlet. This erosion should be arrested before it encroaches into the embankment material.

4.3 Maintenance of Operating Facilities

There are no operating facilities associated with this dam.

4.4 Description of Any Warning System in Effect

The inspection team is not aware of any existing warning system for this dam.

4.5 Evaluation

The operation and maintenance for Westhoff Dam seems to be lacking. The remedial measures as described in Section 7.2 should be undertaken as recommended.

SECTION 5: HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

a. Design

The watershed area of the Westhoff Dam upstream from the dam axis consists of approximately 368 acres. The watershed area is wooded and agricultural land with some pasture and range land. Land gradients in the watershed average roughly 1.5 percent. The Westhoff Dam Reservoir is located on an unnamed tributary of Bobs Creek. The reservoir is about 2 miles upstream from the confluence of the unnamed tributary and Bobs Creek. At its longest arm the watershed is approximately 1.25 miles long. A drainage map showing the watershed and the downstream hazard zone is presented as Plate 1 in Appendix B.

Evaluation of the hydraulic and hydrologic features of Westhoff Dam was based on criteria set forth in the Corps of Engineers' "Engineer Regulation No. 1110-2-106" and additional guidance provided by the St. Louis District of the Corps of Engineers. The Probable Maximum Flood (PMF) was calculated from the Probable Maximum Precipitation (PMP) using the methods outlined in the U.S. Weather Bureau Publication, Hydrometeorological Report No. 33. The probable maximum storm duration was set at 24 hours, and storm rainfall distribution was based on criteria given in the Corps of Engineers' EM 1110-2-1411 (Standard Project Storm). The Soil Conservation Service (SCS) method was used for deriving the unit hydrograph, utilizing the Corps of Engineers' computer program HEC-1 (Dam Safety Version). The unit hydrograph parameters are

presented in Appendix B. The SCS method was also used for determining the loss rate. The hydrologic soil group of the watershed was determined by use of published soil maps. The hydrologic soil group of the watershed and the SCS curve number are presented in Appendix B. The curve number, the unit hydrograph parameters, the PMP index rainfall and the percentages for various durations were directly input to the HEC-1 (Dam Safety Version) computer program to obtain the PMF hydrograph. The computed peak discharges of the PMF and one-half of the PMF are 5,266 cfs and 2,633 cfs, respectively.

Both the PMF and one-half of the PMF inflow hydrographs were routed through the reservoir by the Modified Puls Method also utilizing the HEC-1 (Dam Safety Version) computer program. A storm of 50 percent and 25 percent PMF, respectively, preceded the PMF and the 50 percent PMF by four days. The starting elevation for routing antecedent floods was assumed to be equal to the mean annual high water level in the reservoir. The mean annual high water level for Westhoff Dam Reservoir was estimated to be at the crest of the principal spillway. The water level in the reservoir at the end of the four day routing period was at the same elevation as the crest of the principal spillway. The reservoir was assumed at this level before the start of the routing computation for the PMF and one-half of the PMF. The peak outflow discharges for the PMF and one-half of the PMF are 5,156 and 2,531 cfs, respectively. Both the PMF and one-half of the PMF when routed through the reservoir resulted in overtopping of the "effective top of dam". The "effective top of dam" is defined as the lake elevation at which corresponding outflow velocities exceed the suggested maximum permissible mean velocity in the emergency spillway channel.

The size of physical features utilized to develop the stage-outflow relation for the spillway and overtopping of the dam were determined from field notes and sketches, prepared during the field inspection. The reservoir stage-capacity data were based on the U.S.G.S. Maryknoll and Winfield, Missouri Quadrangle topographic maps (7.5 minute series). The spillway and dam overtop rating curve and the reservoir capacity curve are presented in Plates 2 & 3 respectively in Appendix B.

From the standpoint of dam safety, the hydrologic design of a dam must aim at avoiding overtopping. Overtopping is especially dangerous for an earth dam because of its erosive characteristics. The safe hydrologic design of an embankment dam requires a spillway discharge capability, in combination with an embankment crest height that can handle a very large and exceedingly rare flood without dam overtopping.

The Corps of Engineers designs dams to safely pass the Probable Maximum Flood that is estimated could be generated from the dam's watershed. This is the standard for dam safety where overtopping would pose any threat to human life. Accordingly, the hydrologic requirement for safety for this dam is the capability to pass the Probable Maximum Flood without overtopping.

b. Experience Data

It is believed that records of reservoir stage or spillway discharge are not maintained for this site. However, according to Mr. Westhoff, one of the owners, the maximum reservoir level was about 2 feet above the crest of the emergency spillway.

c. Visual Observations

Observations made of the spillway during the visual inspection are discussed in Section 3.1d and evaluated in Section 3.2.

d. Overtopping Potential

As indicated in Section 5.1.a, both the Probable Maximum Flood and one-half of the Probable Maximum Flood when routed through the reservoir, resulted in overtopping of the "effective top of dam" which was determined to be at El. 469.6 feet above M.S.L. The peak outflow discharges for the PMF and one-half of the PMF are 5,156 and 2,531 cfs, respectively. The capacity of the two spillways just before exceeding the mean permissible velocity of 7 ft/sec. in the emergency spillway is 550 cfs. The PMF overtopped the "effective top of dam" by 1.94 feet and one-half of the PMF overtopped the "effective top of dam" by 1.23 feet. The total duration of overflow over the "effective top of dam" is 5 hours and 55 minutes during the PMF and 3 hours and 40 minutes during one-half of the PMF. The spillway/reservoir system of Westhoff Dam is capable of accommodating a flood equal to approximately 20 percent of the PMF just before overtopping the "effective top of dam". The reservoir/spillway system of Westhoff Dam will accommodate the 100-year flood without going over the "effective top of dam" elevation. The results of routing of various percentages of the PMF and one-percent chance flood are presented in the following Table:

SUMMARY OF ROUTINGS OF VARIOUS FLOODS

Flood Routed	Max. Pool Elevation (Ft. above M.S.L.)	Maximum Discharge (cfs)	Depth Above "Effective Top of Dam" Elevation (ft.)	Duration of Flow Above "Effective Top of Dam" Elevation (hrs.)
13% PMF	468.27	198	0	0
17% PMF	469.23	452	0	0
18% PMF	469.41	507	0	0
22% PMF	469.93	804	0.33	0.67
50% PMF	470.83	2531	1.23	3.67
100% PMF	471.54	5156	1.94	5.92
One-Percent Chance Flood	468.93	362	0	0

The failure of the dam could cause extensive damage to the property downstream of the dam and possible loss of life. The estimated damage zone extends approximately one mile downstream of the dam. Within the damage zone are four dwellings, four buildings, three trailers, a pond and one gas station.

SECTION 6: STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observations

There were no major signs of settlement or distress observed on the embankment during the visual inspection. The embankment is protected against surface erosion by an adequate cover of vegetation. The damage to the upstream and downstream slopes due to the grazing livestock does not appear to affect the structural stability of the dam at this time. Nevertheless, the problem should be corrected and the damage properly repaired. The minor erosion due to wave action on the upstream slope does not appear to affect the structural stability of the embankment in its present condition. Nevertheless, the erosion should be monitored and if the erosion continues, steps should be taken to control the problem. The erosion on the left abutment and upstream of the emergency spillway pose a potential danger to the dam and should be properly repaired. In the absence of seepage and stability analyses, no quantitative evaluation of the structural stability can be made.

Although the interior of the principal spillway conduit could not be visually inspected, it is assumed that the entire conduit was in a functionally stable condition. The outlet end of the pipe and the immediately following downstream channel reach appear to be generally stable, as does the emergency spillway channel. Two specific conditions which should be pointed out are the soft area and vehicular

ruts within the emergency spillway crest area and the erodible conditions in the spillway outlet area; these two conditions pose potential problems to localized stability. Overall, these appurtenances appear to be structurally stable.

b. Design and Construction Data

No design computations pertaining to the embankment were uncovered during the report preparation phase. SCS design computations pertaining to the hydraulic design of the principal spillway and the emergency spillway were located and are included in this report. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available. No embankment or foundation soil parameters are available for carrying out a conventional stability analysis on the embankment. Likewise, construction data relating to the degree of embankment compaction are not available for use in a stability analysis. A standard Soil Conservation Service specification used for Westhoff Dam was located. Nevertheless, no specific information pertaining to the soil type to be used for this dam, degree of compaction to be attained, type of foundation which might be encountered, treatment of the foundation or other information which could be used to evaluate the stability of the dam was in the specification.

c. Operating Records

No operating records were available relating to the stability of the dam or appurtenant structures. The water level on the day of the visual inspection was at the crest of the principal spillway. According to Mr. Westhoff, the reservoir remains full most of the time. No regulated outlet works or low level drain was provided for the dam.

d. Post Construction Changes

No post construction changes have been made to Westhoff Dam.

e. Seismic Stability

The dam is located near the borderline of seismic zones 1 and 2, as defined in "Recommended Guidelines for Safety Inspection of Dams" prepared by the Corps of Engineers, and does not require a seismic stability analysis. An earthquake of the magnitude which would be expected in Seismic Zone 1 or 2 should not cause significant distress to a well designed and constructed earth dam. Available literature indicates no active faults exist in the vicinity of the damsite.

SECTION 7: ASSESSMENT/REMEDIAL MEASURES

7.1

Dam Assessment

The assessment of the general condition of the dam is based upon available data and visual inspection. Detailed investigations, testing and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

It should be realized that the reported condition of the dam is based upon observations of field conditions at the time of inspection along with data available to the inspection team.

It is also important to note that the condition of a dam depends upon numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be assurance that an unsafe condition could be detected.

a. Safety

The spillway capacity of Westhoff Dam is found to be "Seriously Inadequate". The spillway/reservoir system will accommodate only 20 percent of the PMF without overtopping the "effective top of dam". The surface soils in the embankment and the emergency spillway appear to be silty clay. The PMF overtopped the "effective top of dam" by 1.94 feet and one-half of the PMF overtopped the "effective top of dam" by 1.23

feet. The maximum velocity of flow in the emergency spillway will be about 9 ft/sec. The velocity in the emergency spillway will thus exceed the permissible velocity of 7 ft/sec (Kentucky Blue Grass-Silt clay) during overtopping. Since the physical top of dam is also overtopped during the occurrence of the PMF and one-half of the PMF, the dam itself would be susceptible to erosion due to high velocity of flow on its downstream slope.

No quantitative evaluation of the structural safety of the embankment can be made in view of the absence of seepage and stability analyses. The present embankment and appurtenant structures, however, have reportedly performed satisfactorily since its construction without failure or evidence of instability. The dam has reportedly never been overtopped.

The safety of the dam can be improved if the deficiencies described in Section 6.1a and below are properly corrected according to the procedure given in Section 7.2b. The small saplings on the upstream slope could jeopardize the safety of the dam, if they are allowed to continue to grow. Depending on the extent of the root system of large trees, seepage paths can develop along roots of trees which could lead to piping of the embankment material and cause the embankment to fail. The trees can be uprooted during a storm which could cause considerable damage to the dam.

b. Adequacy of Information

The conclusions presented in this report are based upon field measurements, limited design drawings, past performance and the present condition of the dam. Information on the operation and maintenance of the dam were not available.

Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were also not available which is considered a deficiency.

c. Urgency

The remedial measures recommended in Paragraph 7.2 should be accomplished within a reasonable period of time. The items recommended in paragraph 7.2a should be pursued on a high priority basis.

d. Necessity for Phase II Inspection

Based upon results of the Phase I inspection, and if the remedial measures recommended in Paragraph 7.2 are undertaken, a Phase II inspection is not felt to be necessary.

7.2 Remedial Measures

a. Alternatives

There are several general options which may be considered to reduce the possibility of the dam failure or to diminish the harmful consequences of such a failure. Some of these options are:

1. Increase spillway capacity to pass the probable maximum flood without overtopping the dam.
2. Provide a highly reliable flood warning system (generally does not prevent damage but avoids loss of life).

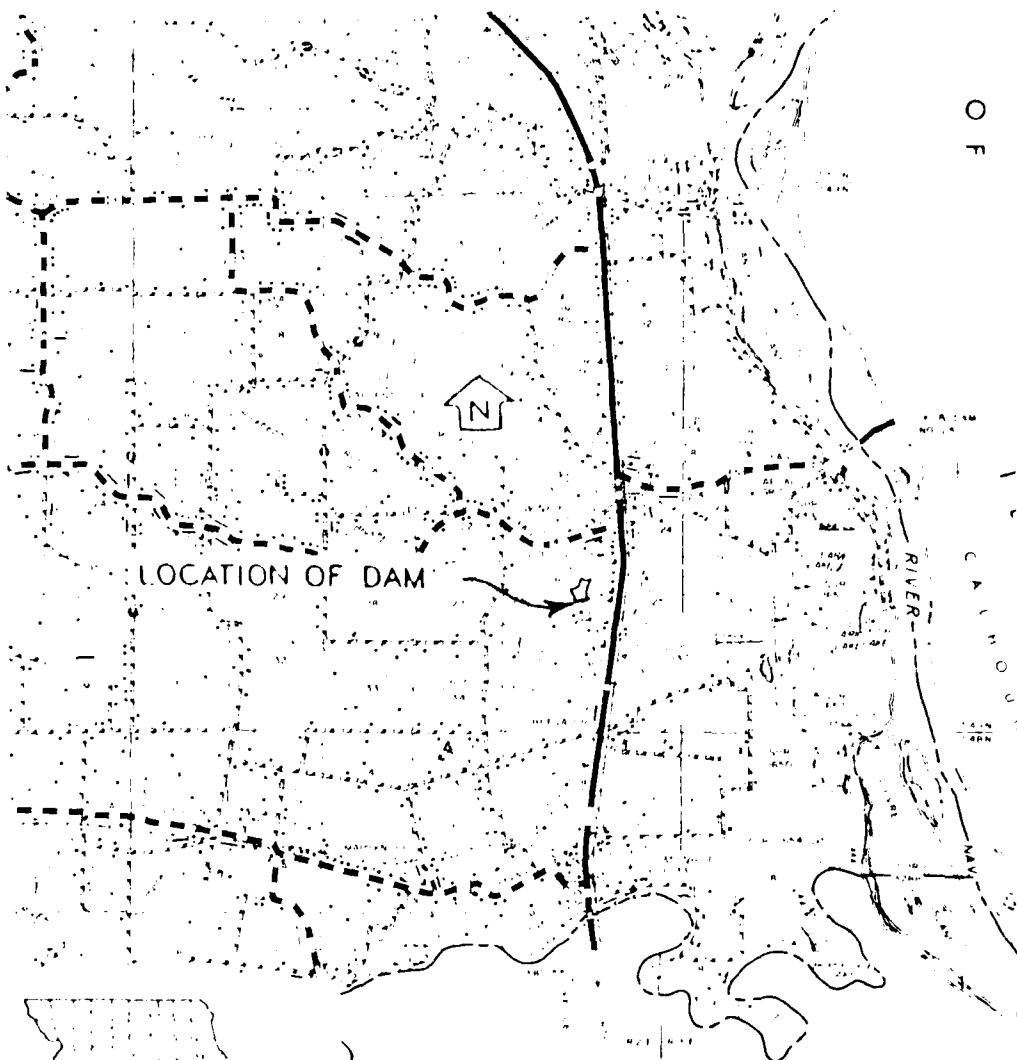
b. O & M Procedures

1. Grazing livestock should be prevented access to the embankment. The damage caused by the livestock should be properly repaired and adequately protected from further damage.
2. The erosion gullies on the left abutment and upstream of the emergency spillway should be back-filled with a suitable material, properly compacted and protected from further erosion.
3. The minor erosion on the upstream slope due to wave action should be monitored and corrective measures taken when deemed necessary.
4. The small saplings on the upstream slope near the shoreline should be cut and the root systems treated to prevent further growth.
5. The emergency spillway crest should be repaired to the extent that it is in as good and stable a condition as the channel portion of the spillway.
6. Once livestock are prevented from trampling about the downstream slope in the vicinity of the principal spillway outlet, grasses could resume growth; however, this condition should be periodically checked and remedied as required to prevent serious erosion from occurring.

7. The principal spillway inlet approachway area should be cleaned of dead grass, etc., and periodically checked for accumulations of miscellaneous brush and rubbish which could reduce spillway capacity.
8. Seepage and stability analyses should be performed by a professional engineer experienced in the design and construction of earth dams.
9. The owner should initiate the following programs:
 - (a) Periodic inspection of the dam by a professional engineer experienced in the design and construction of earthen dams.
 - (b) Set up a maintenance schedule and log all visits to the dam for operation, repairs and maintenance.

PLATES

PLATE I



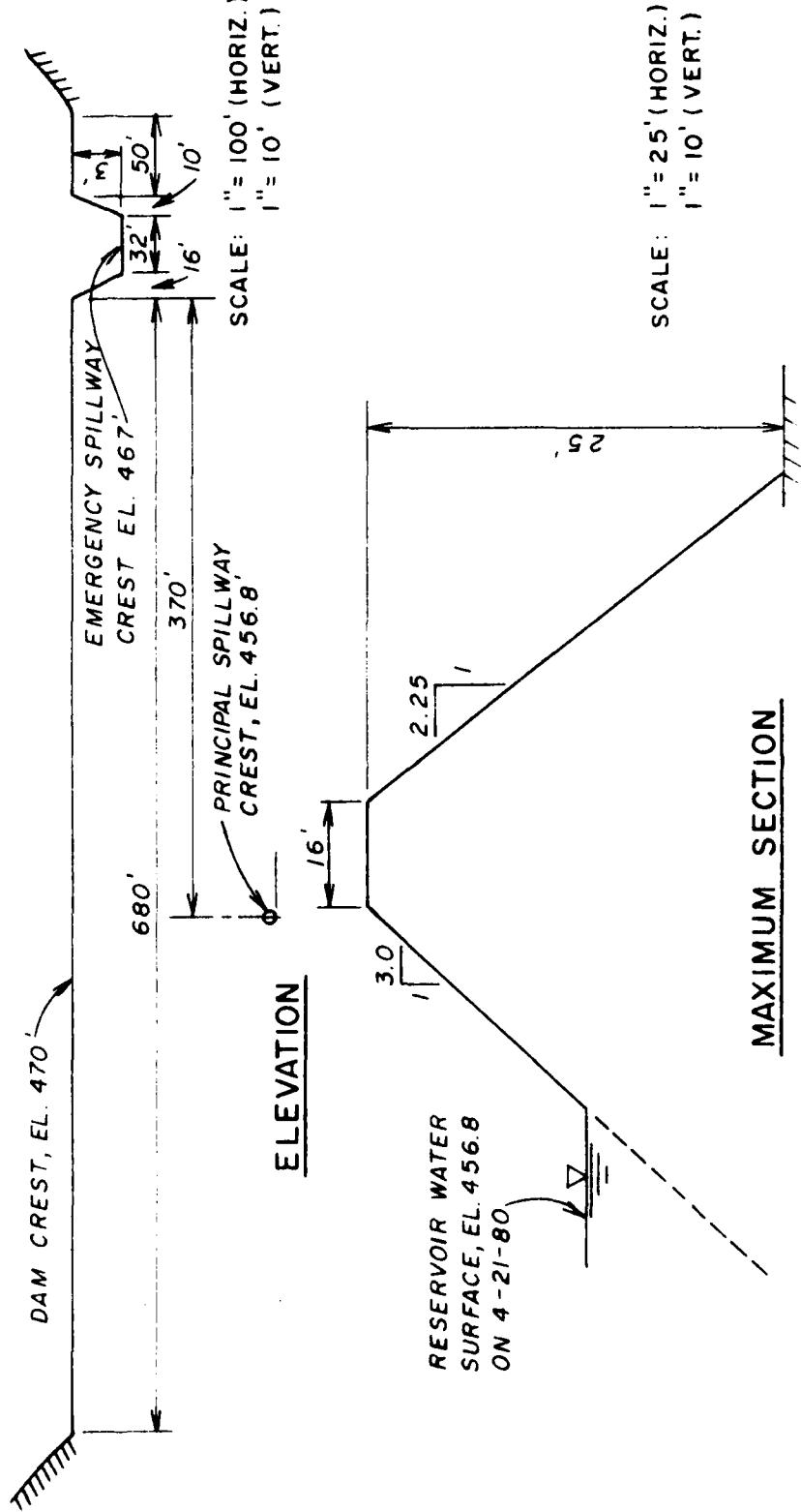
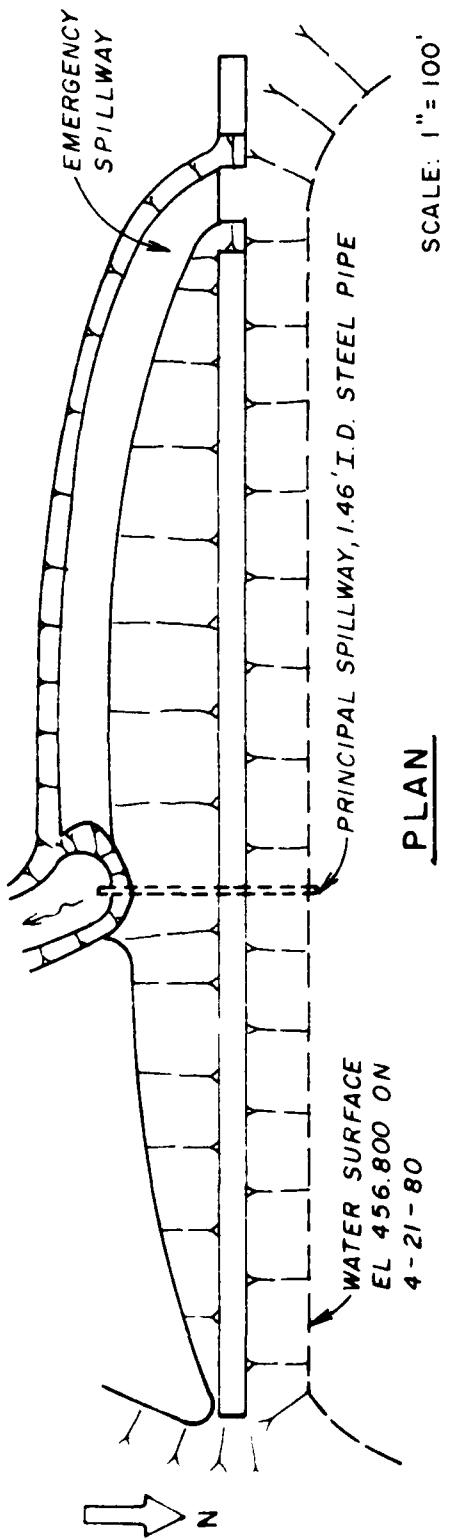
KEY MAP
SHOWING LOCATION OF COUNTY

LINCOLN COUNTY

SCALE
FEET MILES

LOCATION MAP - WESTHOFF DAM
MO. 11140

PLATE N



WESTHOFF DAM (MO. 11140)
PLAN, ELEVATION AND SECTION

U.S. GOVERNMENT PRINTING OFFICE

PLATE 3

DRY CREEK, NEAR THE CITY OF LINCOLN, NEBRASKA
AND THE KANSAS CITY, MO., AND SPILLWAY - CREEK INLET SPILLWAY

By name LEONARD WESTHAFF Jr. location LINCOLN,
Nebraska Date Oct 7th Checked by [initials] Date _____
Drainage area 368 ac. straight x storage = _____ x _____

WATERFALL CONDITIONS AND FACTORS

Land slope	L = 1.5
Infiltration (above) (average) (below)	I = 0.2
Total slope (drainage area) average slope	I = 2.72
Storage capacity (ft.) 6,000 ft.	S = 1.1
Cover (soil content 40%, pasture 40%, timber 20%)	V = 0.8
Controlled flow	C = 1.0
Storage factor (determined)	P = 1.0

PLAN FACTOR OR RATIO AND VOLUME OF RUNOFF

Product of rainfall (1 ft.) X SLOPE X P = 0.73 Q₁₀ = 5.2 / c.f.s.

$$0.73 \times 0.8 \times 0.9 = 0.72$$

Flow factor (Q₁₀) = 1.0

$$0.72 \times 1.0 = 0.72 \text{ c.f.s.} = 11.5 \text{ ac.ft./c.f.s.}$$

Flow factor (Q₁₀) = 0.104 ac.ft./ac. (Table 1, 1919)

Total flow factor (Q₁₀) = (drainage area)/rate of volume of runoff) X L =

$$0.104 \text{ ac.ft./ac.} \times 1.0 = 3.83 \text{ ac.ft.}$$

Flow factor (Q₁₀) = 1.0

$$0.72 \times 1.0 = 0.72 \text{ c.f.s.} = 7.16 \text{ c.f.s.}$$

Flow factor (Q₁₀) = 0.104 ac.ft./ac.

$$0.368 \text{ ac.} \times 0.104 \text{ ac.ft./ac.} \times 1.0 = 64 \text{ ac.ft.}$$

Flow factor (Q₁₀) = 1.0

Flow factor (Q₁₀) = 1.0 (for possibility for applicable structure). File
plan in engineer's plan in engineer's or landowner's folder in

PLATE 4

EMERGENCY SPILLWAY DESIGN

Available storage at streamer = 7.6 ft. V_s = 31.7 ac.ft. (See map)

$$V_{sp}/V_r = \underline{36.7} \text{ ac.ft.} / \underline{48.3} \text{ ac.ft.} = \underline{0.758}, Q_{op}/Q_{ip} = \underline{0.92} \text{ (Table 2, 1519)}$$

$$Q_{op} = Q_{ip} \times \underline{531} = \underline{531} \text{ c.f.s.} \times \underline{0.92} = \underline{10.6} \text{ c.f.s.}$$

Conduit:

Type S18, Length = 10.5 ft. Total head on conduit = 2.12 ft.

Diameter = 18 in. Discharge capacity = 26 c.f.s. (1520)

Minimum entrance head = 2.3 ft. (1510 or 1511) $D_{RAT} = D_{min} + 2.3$ ft. = 18.3 ft.

Riser: **

Type V 1/4, Height = 12 ft. Diameter = 12 in. (1511)

EMERGENCY SPILLWAY DESIGN

Control Section:

Depth of flow = 2.0 ft. V_s at this depth = 48.1 ac. ft. (See map)

$$V_r/V_s = \underline{48.1} \text{ ac.ft.} / \underline{48.1} \text{ ac.ft.} = \underline{1.0}$$

$$Q_{op}/Q_i = \underline{2.5} \text{ c.f.s.} / \underline{7.96} \text{ c.f.s.} = \underline{0.3}, Q_{oe}/Q_i = \underline{0.19} \text{ (Table 3, 1519)}$$

$$Q_{oe} = Q_i \times \underline{0.19} = \underline{7.96} \text{ c.f.s.} \times \underline{0.19} = \underline{1.51} \text{ c.f.s.}$$

Width = 20 ft. Total depth = depth of flow + freeboard = 2.0 ft. + 1.0 = 3.0 ft. Use 3.0 ft. (Table 4, 1517)

Exit Section:

Slope = 1% Quality of vegetation: (fair) (good) (excellent) *

(less) (more) * erosive soils. Permissible velocity = 10 f.p.s. (1517)

Depth = 1.0 ft. Design velocity = 10 f.p.s. Width = 10 ft. (1517 or 1505)

Use width of 10 ft.

COLLAR SPILLWAYS

Length of saturated zone = $L = 84$ ft. Collar addition = 4 ft. (1515)

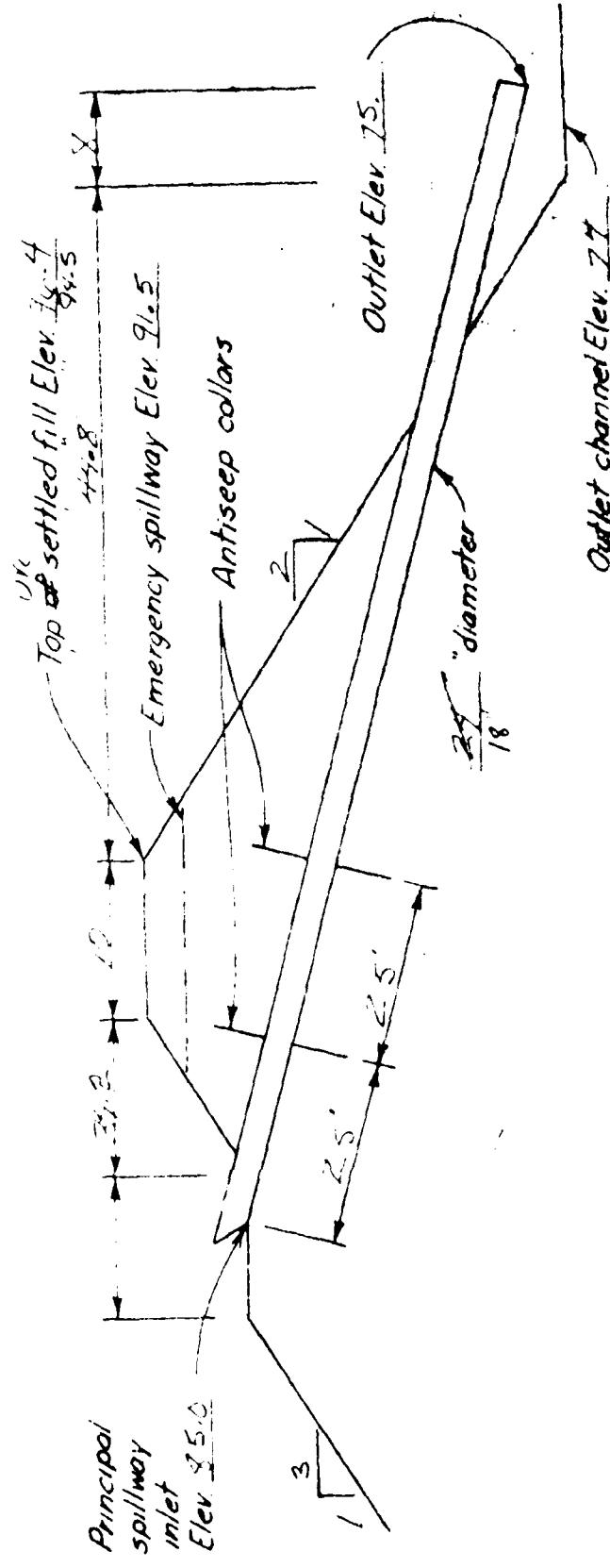
$$\text{Number of n} = (L \times 0.1) / V = (84 \times 0.1) / 1.4 = 6.0, \text{ Use } 2 \text{ collars.}$$

$$5.5' \times 5.5'$$

* Mark out those items that do not apply.

** Applies only to Drop 1st Spillways.

W3-ENG-313 Pg. 2173 File Code : ENG-13



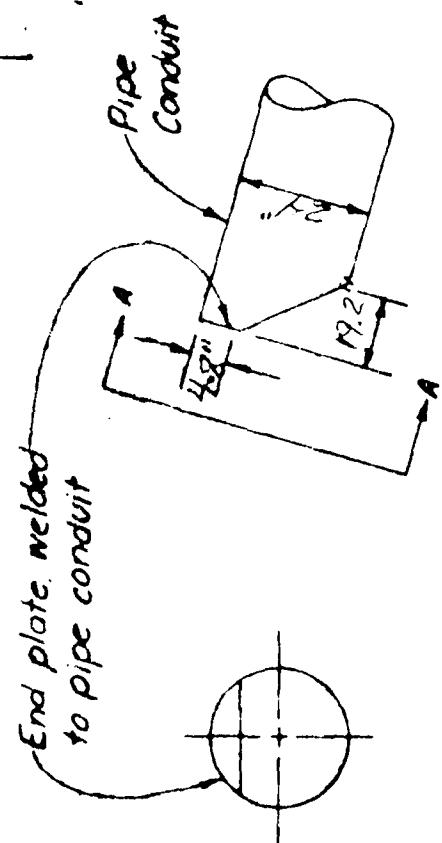
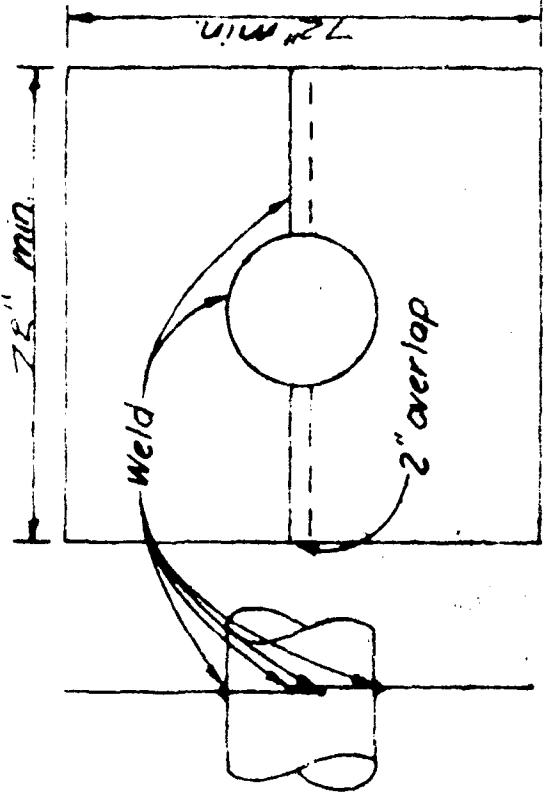
SECTION ALONG & PRINCIPAL SPILLWAY

Not to Scale

ESTIMATED QUANTITIES

Landowner	John J. Smith	Date	6-25-51
Designed by	John J. Smith	Date	6-25-51
Checked by	John J. Smith	Date	6-25-51
Approved by	John J. Smith	Date	6-25-51
Sheet 3 of 3		6-27-51	

- Notes
- 1 All welds shall be watertight.
 - 2 All pipe and steel plates shall have minimum thickness of 10 ga or 0.135 inches

ANTI-SEEP COLLARNot to Scale

COOPERATION / HISTORIC JR SEC
COOPERATING WITH LACROSSE, WI.
CITY OF LACROSSE
COUNTY OF DODGE
STATE OF WISCONSIN
SURVEYED & DRAWN BY E. C. BROWN & CO.

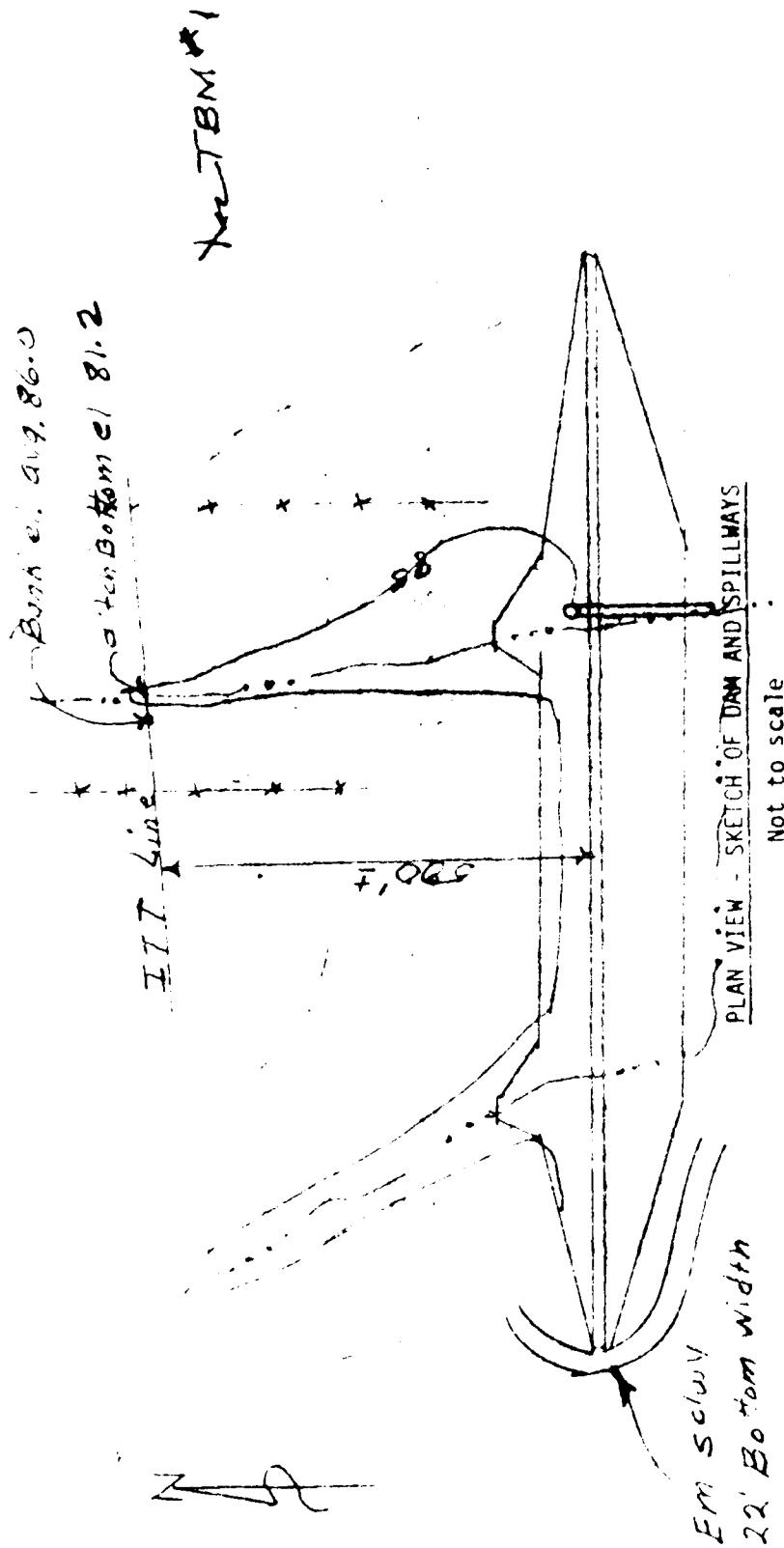
DETAILS FOR WELDED STEEL
CANOPY INLET SPILLWAY

SECTION A-A
INLET SECTION

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

DATE	1954
DESIGNER	E. C. BROWN
CONTRACTOR	
APPROVED	

5-L-28, 1954



UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Approximate surface area 1.9 acres.

Permanent pool elevation 85.0.

TBM No. 1 Elev. 80 Description 1/2 Nail at Base
of 42' Elm Tree in Field Approx. 200'
Ac. of Farm Field and a part of 200'
Elm at N.H. Description 1/2 Nail at Base

Landowner Leonard Westhoff Jr.
County Missouri
Designed by Lincoln
Checked by Lake
Approved by _____
Sheet 3 of 3

5.1-28.922

PLATE 8

MO-15 (Formerly MO-69 & MO-248)
5/15/69Date _____
By _____ Ck _____

U.S. DEPARTMENT OF AGRICULTURE - SOIL CONSERVATION SERVICE - COLUMBIA, MO.

EARTH WORK COMPUTATION SHEETOwner or
Watershed Leavenworth Co. Mo. Location or Sub-Watershed _____
Structure Number _____

Upstream _____

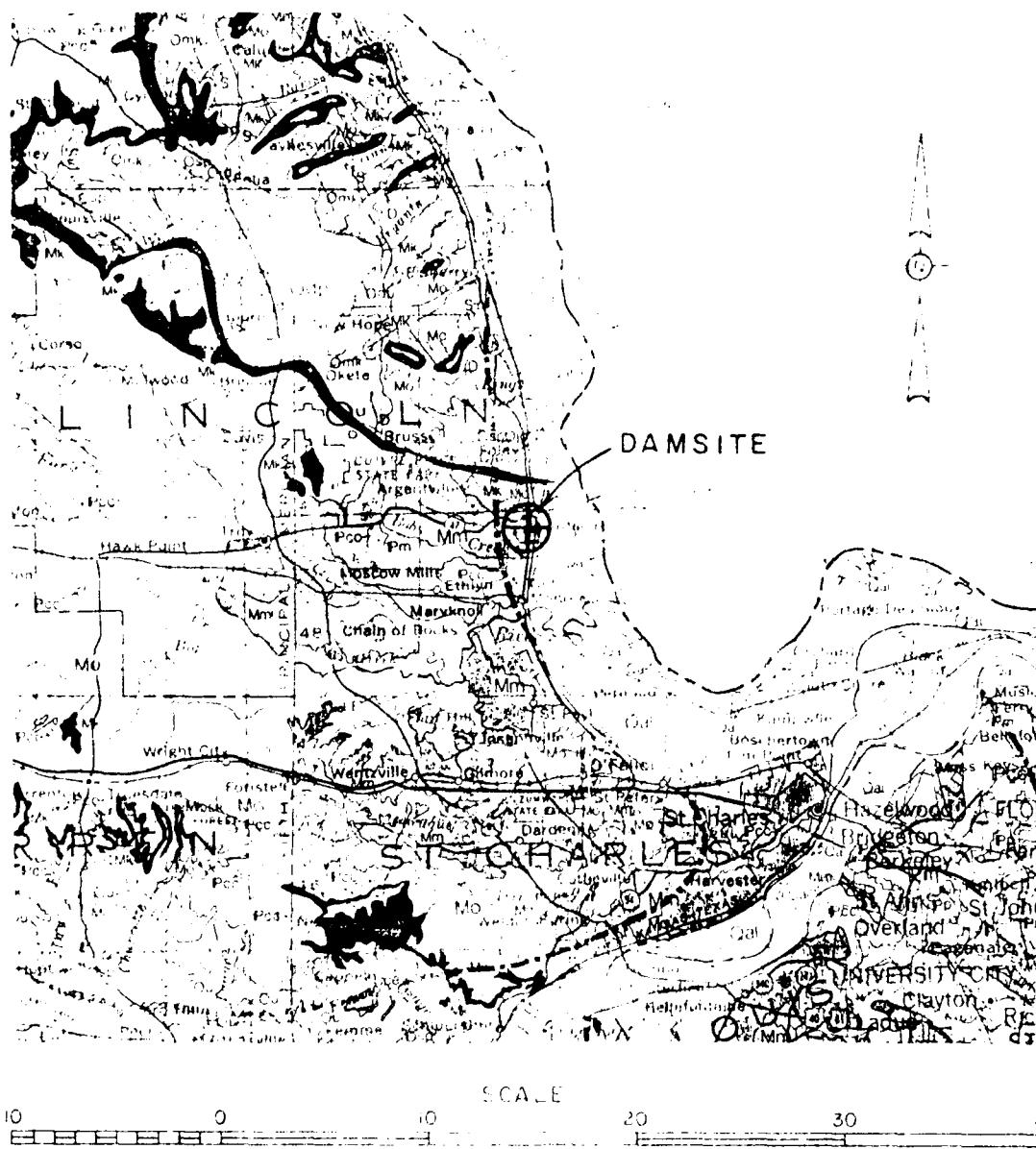
Top of Fill; Width 12; Elev. 97.5; Slopes - Downstream _____

Upstream Berm; Width _____ Elev. _____; Downstream Berm; Width _____ Elev. _____

Station	Ground Elev. ft. G	Fill Hgt. Ft.	Fill Yd.3/ Ft.	Berm Hgt. Ft.	Berm Yd.3/ Ft.	Total Fill Yd3/Ft.	Sum Fill Yd3/Ft.	Dist. between Stns.	Double Fill Yd.3
+20	97.5	3	3			0	XXXXXXX	XXXXXX	XXXXXXX
2+5	100.5	3.0				5.6	5.6	10	616
2+9	101.1	4.9				11.7	11.7	6	1211
3+0	102.3					13.1	25.9	12	1527
3+4	103.1					13.1	39.0	12	544
3+8	103.1					13.1	52.1	12	819
4+0	103.1					40.7	40.7	12	918
4+3	104.0	10.1				15.1	25.8	9	2710
4+6	104.4					13.1	38.9	12	3252
5+0	104.4	10.1				13.1	52.0	12	688
5+3	104.6					13.1	65.1	12	1140
5+6	104.8					13.1	78.2	12	471
6+0	105.2					13.1	92.0	12	1522
6+3	105.8					8.5	110.0	8	830
7+0	106.5					2.5	4.4	50	220
7+3	107.0	3.0				1.9	5.9	50	115
						Total Double Fill	153.6		
						Total Fill	8164		

Allow 20 % for Settlement.
Side Spillway Fill (Including Dikes) _____
Backfill Core Trench Exc.
Backfill Structure Exc.
Backfill Stripping
Class _____ Total . . .

PLATE 9



⊕ LOCATION OF DAM

NOTE LEGEND OF THIS DAM IS ON PLATE

REFERENCE

GEOLOGIC MAP OF MISSOURI
DEPARTMENT OF NATURAL RESOURCES
MISSOURI GEOLOGICAL SURVEY
KENNETH H ANDERSON, 1979

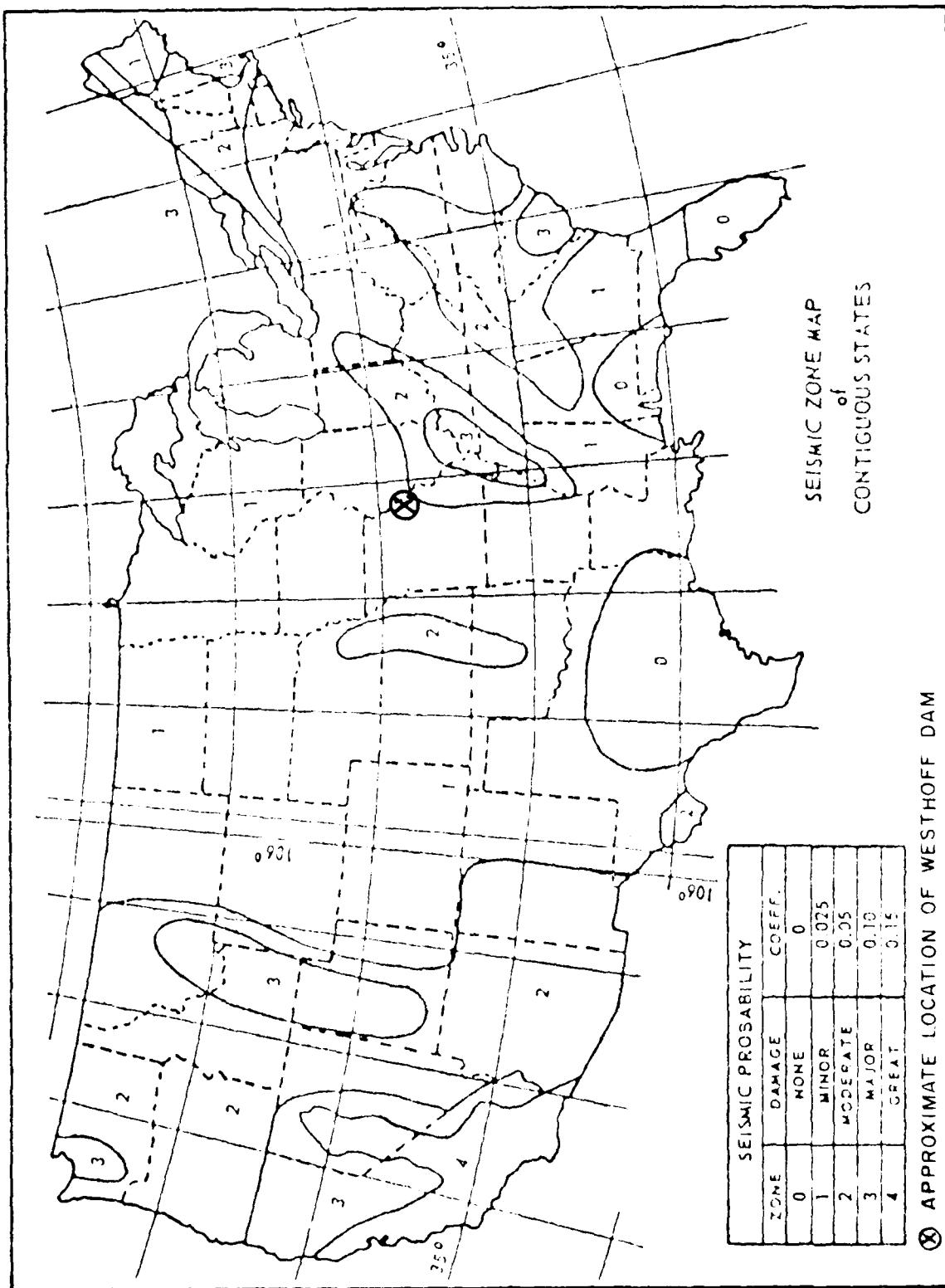
REGIONAL GEOLOGICAL MAP
OF
WESTHOFF DAM

PLATE 10

LEGEND

<u>PERIOD</u>	<u>SYMBOL</u>	<u>DESCRIPTION</u>
QUATERNARY	Qal	ALLUVIUM: SAND, SILT, GRAVEL
PENNSYLVANIAN	Pm	MARMATON GROUP: CYCLIC DEPOSITS OF SHALE, LIMESTONE AND SANDSTONE
	Pcc	CHEROKEE GROUP CYCLIC DEPOSITS OF SHALE, LIMESTONE AND SANDSTONE
MISSISSIPPIAN	Mm	ST. LOUIS FORMATION: LIMESTONE INTERBEDDED WITH SHALE
	Mm	SALEM FORMATION: LIMESTONE INTERBEDDED WITH SHALE AND SILSTONE
	Mm	WARSAW FORMATION: ARGILLACEOUS LIMESTONE AND CALCAREOUS SHALE
	Mo	KEOKUK- BURLINGTON FORMATION: CHERTY GRAYISH BROWN SANDY LIMESTONE
	Mk	NORTHVIEW- COMPTON AND BACHELOR FORMATION
DEVONIAN	D	CHATTANOOGA SHALE, SYLAMORE SANDSTONE
ORDOVICIAN	Omk	MAQUOKETA SHALE , KIMMSWICK LIMESTONE
	OdP	DECORAH FORMATION GREEN TO GRAY CALCAREOUS SHALE WITH THIN FOSSILIFEROUS LIMESTONE

PLATE II



APPENDIX A

PHOTOGRAPHS

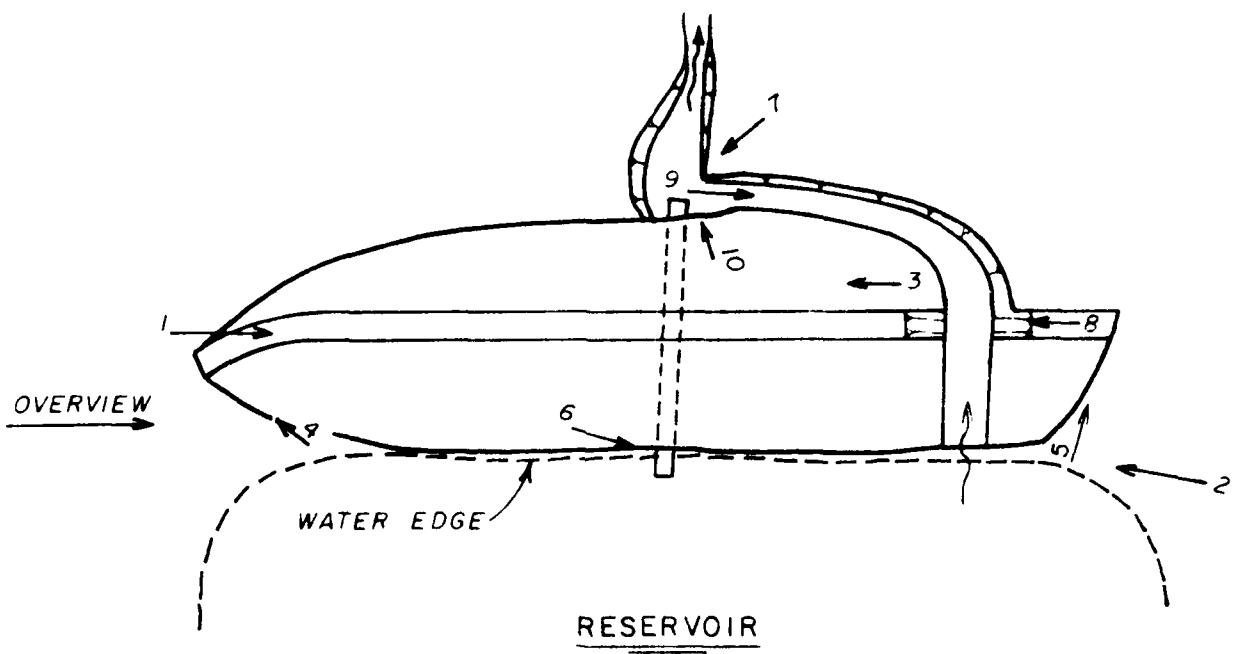


PHOTO INDEX
FOR
WESTHOFF DAM

Westhoff Dam

Photographs

- Photo 1 - Top of dam, showing grass cover protection and vehicular tracks worn into dam surface.
- Photo 2 - Upstream slope of dam showing adequate grass cover and rough edges of berm from dead grass accumulation.
- Photo 3 - Downstream slope of dam showing grass cover, livestock trails and emergency spillway discharge channel, looking downstream.
- Photo 4 - Erosion gully, upstream left abutment contact area.
- Photo 5 - Erosion gully, upstream right abutment contact area.
- Photo 6 - Principal spillway inlet showing nearby brush and plant growth.
- Photo 7 - Principal spillway outlet showing sparseness of grass cover protection and hoof marks of thirsty livestock.
- Photo 8 - View of emergency spillway inlet crest showing soft area, stock trail, and emergency spillway discharge channel along toe of embankment.
- Photo 9 - View of emergency spillway discharge channel (looking upstream) along toe of embankment. (Erosion bottom right.)
- Photo 10 - View of intersection of emergency discharge channel (right foreground) and outlet pipe for principal spillway, and downstream channel brush, etc.

Westhoff Lake Dam



Photo 1



Photo 2

Westhoff Lake Dam

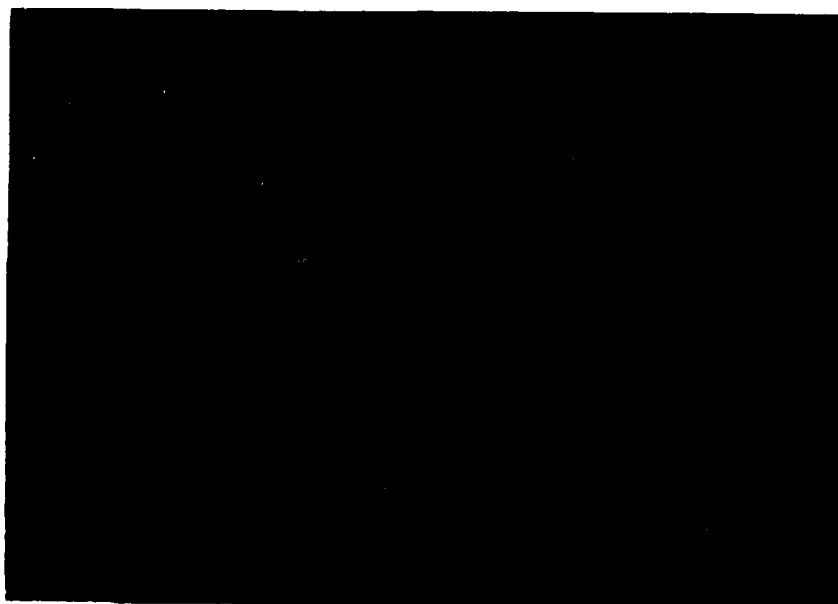


Photo 3

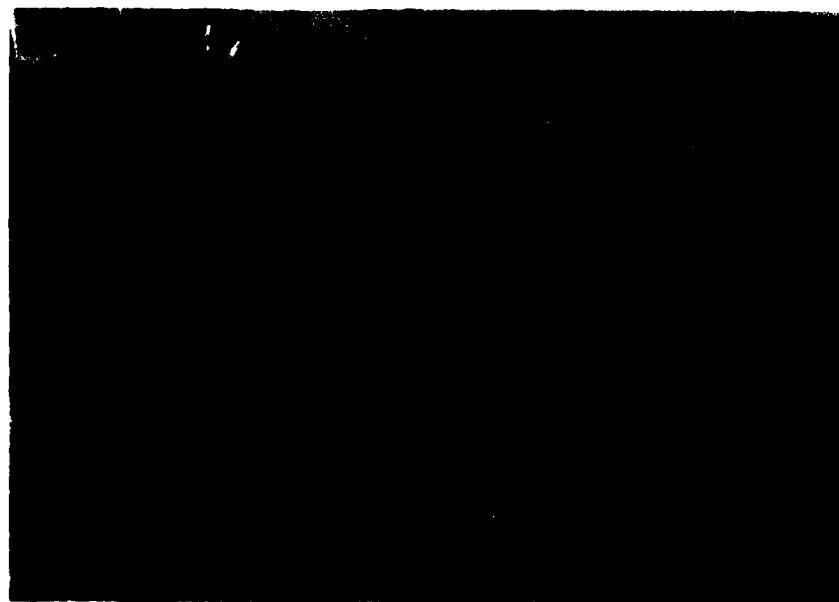


Photo 4

Westhoff Lake Dam

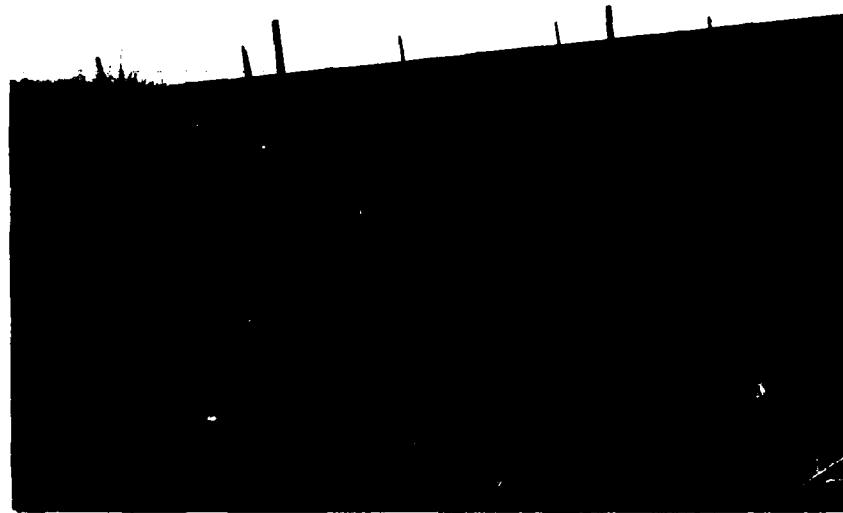


Photo 5

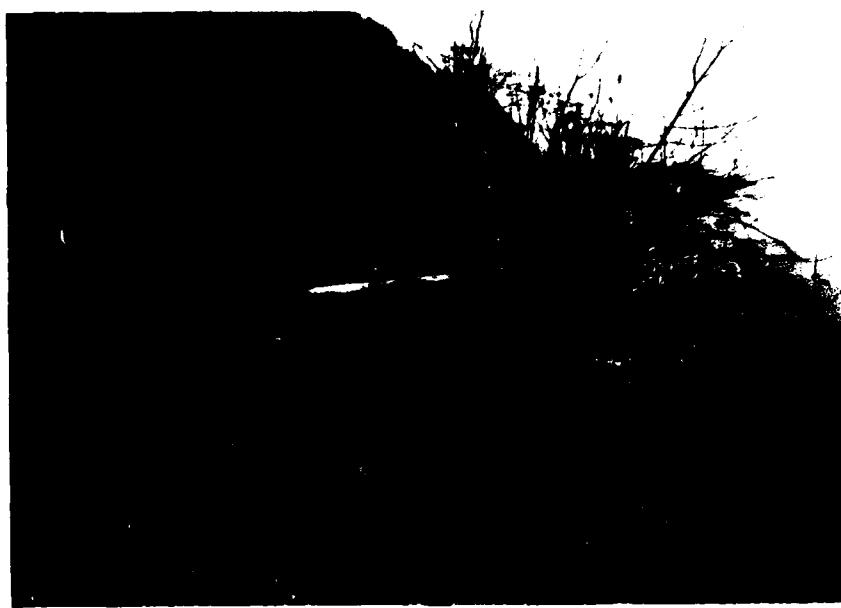


Photo 6

Westhoff Lake Dam



Photo 7



Photo 8

Westhoff Lake Dam



Photo 9

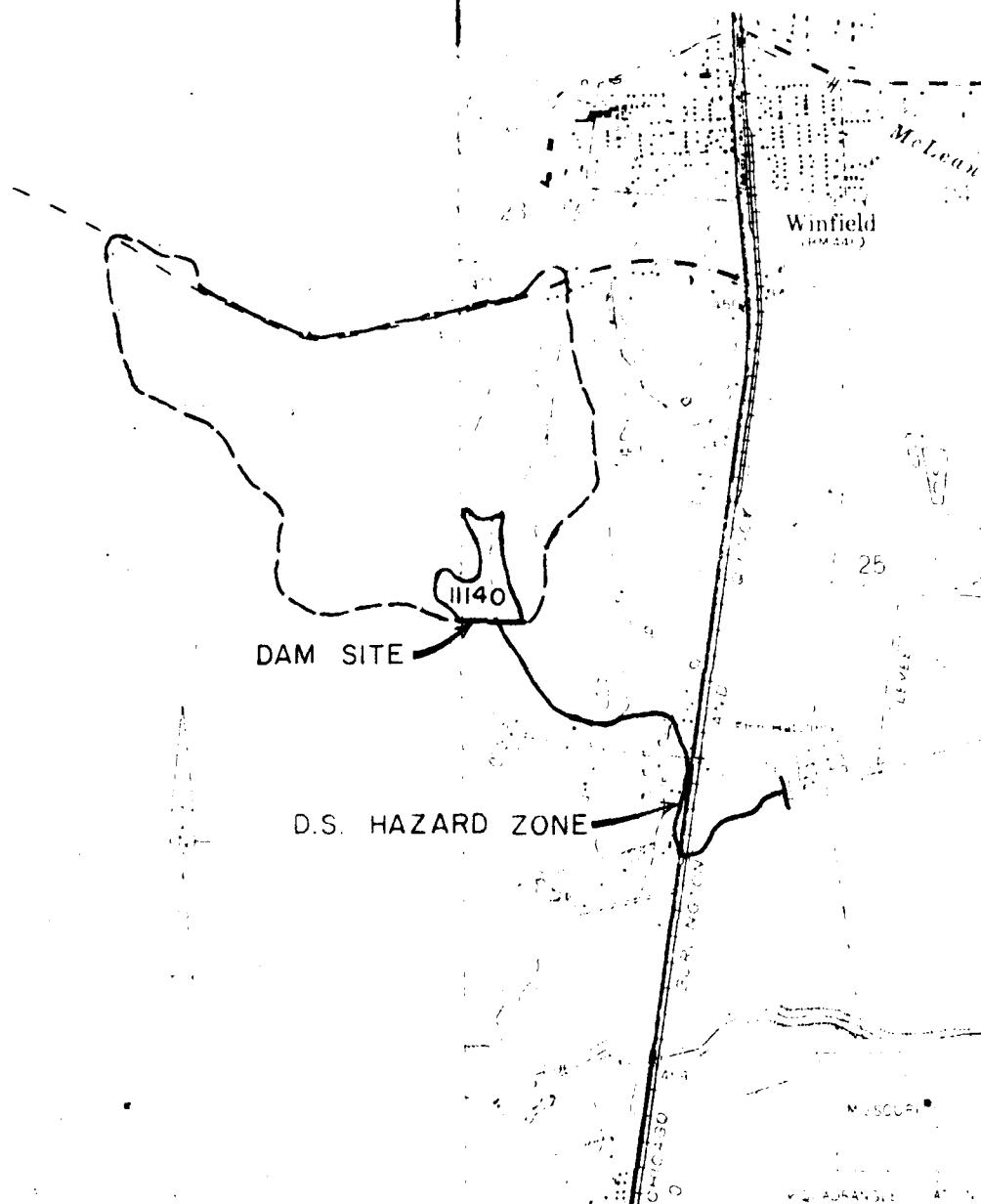


Photo 10

APPENDIX B
HYDROLOGIC AND HYDRAULIC COMPUTATIONS

PLATE I, APPENDIX B

MARYKNOX QUADRANGLE ————— WINFIELD QUADRANGLE



WESTHOFF DAM MOIII40
DRAINAGE BASIN

B-2

PRC ENGINEERING CONSULTANTS, INC.

LAM SAFETY INSPECTION - MISSOURI

SHEET NO. 1 OF 3

WESTHOFF LAM, MO 11140)

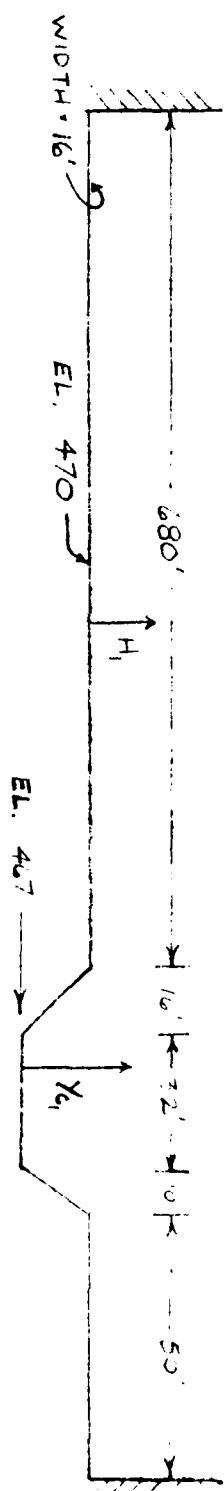
JOB NO 1263

SPILLWAY AND OVERLORD RATING CURVE

BY JFK DATE 9/29/80

X_C	A_C	T_C	$V_{C1}^{2.5} \sqrt{\frac{A}{T}}$	$V_{C1}^2/2g$	$Q_{C1} = A_C V_{C1}$	$U/S = \frac{V_{C1}^2/2g}{V_{C1}^2/2g + 9.81/0.03}$	C_*	H_1	$Q_1 = C_* H_1^{3/2}$	$Q_T = Q_1 + Q_1$
0	0	0	0	0	0	46.7	-	-	-	0
1	36.3	40.7	5.4	0.45	196.0	468.45	-	-	-	196
2	81.3	49.3	7.3	0.82	593.5	462.82	-	-	-	594
2.5	107.1	53.7	8.0	1.0	856.8	470.5	270	730	6.5	30.9
3	135.	58.0	8.7	1.16	1174.5	471.16	2.04	730	11.6	240.8
4	193	58.0	10.3	1.66	1987.9	472.06	2.63	730	2.60	832.2
5	251	58.0	11.8	2.16	2961.8	474.16	2.05	730	4.0	1628.9
6	309	58.0	13.1	2.66	4047.9	475.66	2.63	730	5.5	292.3

* Values of C_* are taken from
Table 5-3 "Handbook of Hydrology"
E.P. Blodget & M.W. Kibler, 2nd Edn.



20 ENGINEERING CONSULTANTS, INC.

DAM SAFETY INSPECTION, Missouri - 1980

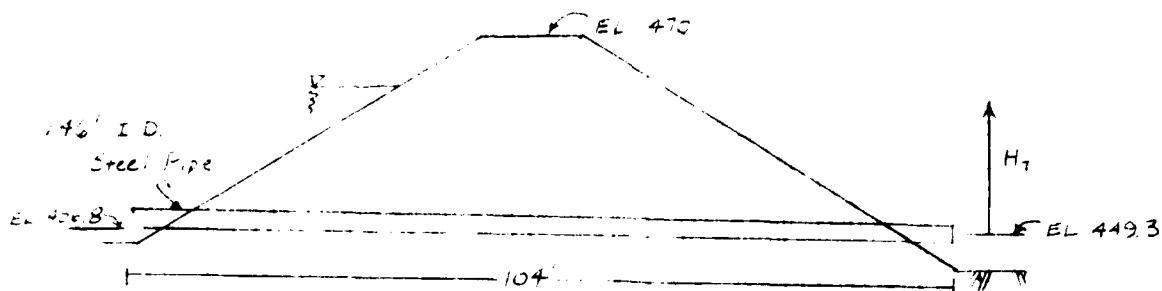
SECTION 2 .. 3

WESTHORFF DAM (MS 114-5)

STATION 1263

MANHATTAN RAILWAY RATING CURVE

DATE JUNE 5/30/80



$$H_T = (K_{exit} + K_{entrance} + K_{D,pe} L) V^2 / 2g$$

$$K_{exit} = 1.0$$

$$K_{entrance} = 1.0 \text{ (Hooded Inlet)}$$

$$K_{D,pe} = 5087 \frac{V^2}{d_L^{4/3}}, \text{ where } n = 0.010 \neq d_L = 17.5"$$

$$= 0.0112$$

$$H_T = (1.0 + 1.0 + 0.0112 \cdot 0.4) \frac{V^2}{2g}$$

$$H_T = 3.165 \frac{V^2}{2g}$$

$$V = 451 \sqrt{H_T}$$

$$Q = VA = \pi \frac{(1.46)^2}{4} V$$

$$Q = 7.54 \sqrt{H_T}$$

PRC ENGINEERING CONSULTANTS, INC.

DAM SAFETY INSPECTION /MISSION VALLEY

LAUREL HILL DAM (ECC 1000)

COMBINED FLOODING CURVE

SHEET NO. 3 OF 3

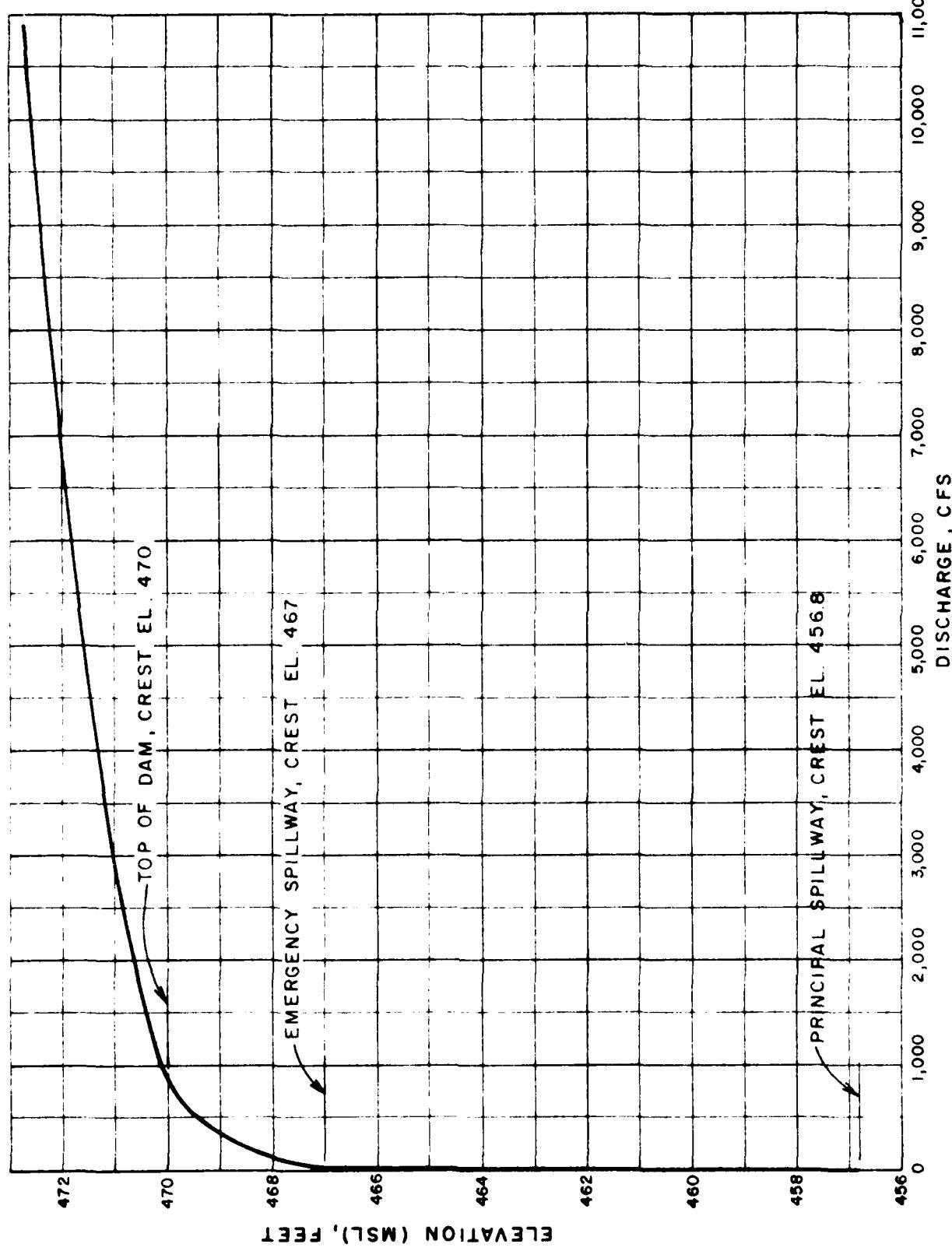
JOB NO. 1165

BY D.C. DATE 6-1-81

Datum = 4/93

Reservoir Water Surface Elev.	H_T	Principal Spillway Discharge $Q = 754 \sqrt{H_T}$	Emergency Spillway Discharge	Discharge Over Top of Dam	Combined Discharge
45.0	-	0	0	0	0
46.0	16.7	24.0	0	0	24
46.5	18.7	27.2	0	0	27.2
47.0	17.7	31.7	0	0	31.7
47.5	19.2	32.0	19.6	0	22.9
48.0	20.5	24.14	593.5	0	628
48.5	21.2	24.72	256.2	696.9	1588
49.0	21.9	25.29	111.5	247.8	341.8
49.5	22.4	36.47	11.72	282.2	173.54
50.0	24.7	37.62	2.111	16287.9	17289
50.5	26.4	35.74	41647	25852.5	10929

PLATE 2, APPENDIX B



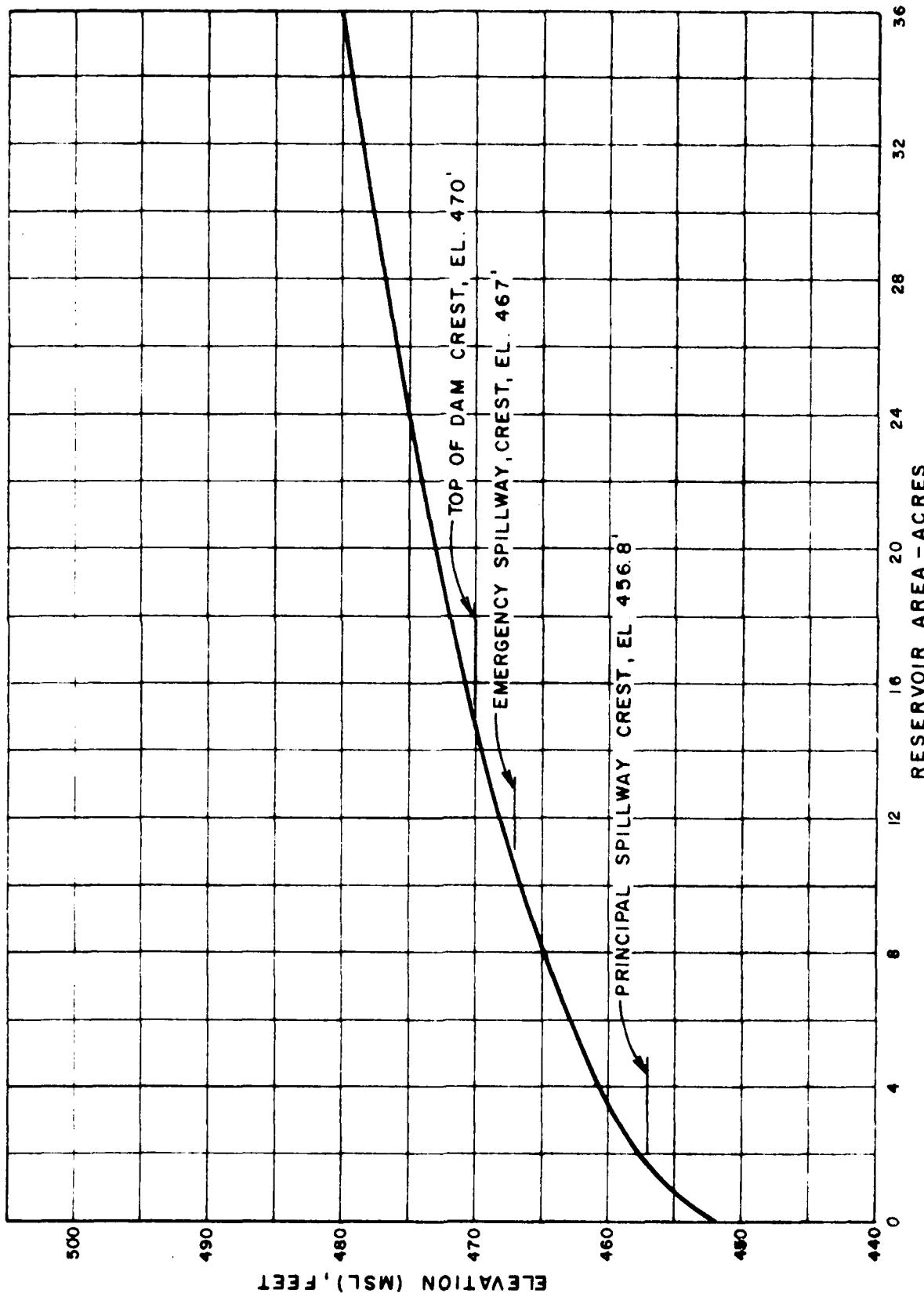
WESTHOFF DAM (MO. 11140)
SPILLWAY & OVERTOP RATING CURVE
S-C

EC-1-4 PRC ENGINEERING CONSULTANTS, INC.

DAM SAFETY INSPECTION - MISSOURI SHEET NO. 1 OF 1
 Dam Name: WESIHOFF DAM LID NO. : MO 1114-1 JOB NO. 1263
 RESERVOIR ELEVATION AREA DATA BY JFK DATE 4/21/80

ELEV. (M.S.L.) (Fe)	RESERVOIR SURFACE AREA (Acres)	REMARKS
452	0	Estimated Streambed at Dam
456.0	1.9	Princip. Spillway Crest
460	3.5	Area Measured on USGS Map
462	9.0	Interpolated from Graph.
467	10.5	Emergency Spillway Crest
470	14.5	Top of Dam
475	24.0	Interpolated from Graph
480	36.0	Area Measured on USGS Map

PLATE 3, APPENDIX B



WESTHOFF DAM (MO. 11140)
RESERVOIR ELEVATION-AREA CURVE
P.D.

ECI-4 PRC ENGINEERING CONSULTANTS, INC.

DAM SAFETY INSPECTION / MISSOURI

SHEET NO. 1 OF 1

DAM NAME: WESTHOFF DAM (MO 11140)

JOB NO. 1263

UNIT HYDROGRAPH PARAMETERS

BY JEF DATE 5/5/80

1) DRAINAGE AREA, $A = 0.58 \text{ sq. mi} = (368 \text{ acres})$

2) LENGTH OF STREAM, $L = (3'' \times 2000' = 6000') = 1.14 \text{ mi.}$

3) ELEVATION AT DRAINAGE DIVIDE ALONG THE LONGEST STREAM,

$$H_1 = 565$$

4) ELEVATION OF RESERVOIR AT SPILLWAY CREST., $H_2 = 456.8$

5) ELEVATION OF CHANNEL BED AT $0.85L$, $E_{85} = 540$

6) ELEVATION OF CHANNEL BED AT $0.10L$, $E_{10} = 475$

7) AVERAGE SLOPE OF THE CHANNEL, $S_{AVG} = (E_{85} - E_{10}) / 0.75L = 540 - 475 / 4500 = 0.015$

8) TIME OF CONCENTRATION:

A) BY KIRPICH'S EQUATION,

$$t_c = [(11.9 \times L^3) / (H_1 - H_2)]^{0.385} = [11.9 \times (1.14)^3 / (565 - 456.8)]^{0.385} = 0.50 \text{ hr}$$

B) BY VELOCITY ESTIMATE,

$$\text{SLOPE} = 0.015 \Rightarrow \text{AVG. VELOCITY} = 2 \text{ f/s}$$

$$t_c = L/v = 6000 / (2 \times 3600) = 0.83 \text{ hr}$$

USE $t_c = 0.50$

9) LAG TIME, $t_l = 0.6 t_c = 0.6 \times 0.5 = 0.30$

10) UNIT DURATION, $D \leq t_c / 3 = 0.50 / 3 = 0.10 \neq 0.083 \text{ hr.}$

USE $D = 0.083$

11) TIME TO PEAK, $T_p = D/2 + t_c = 0.083/2 + 0.30 = 0.34$

12) PEAK DISCHARGE,

$$q_p = (484 \times A) / T_p = 484 \times 0.58 / 0.34 = 826 \text{ cfs}$$

PRC ENGINEERING CONSULTANTS, INC.

DAIRY CATTLE LUMBER CO., / MARYSBURG SHEET NO. 1 OF 3
 DAM NAME: WESTHOFF DAM (MO 11140) JOB NO. 1422
 PROBABLE MAXIMUM FLOOD CONDITION BY JFK DATE 5/5/80

DETERMINATION OF PMP

- 1) Determining drainage area of the basin

$$D.A. = 0.58 \text{ sq. mi}$$

- 2) Determining PMP Index Rainfall (for D.A. = 200 sq. mi. & 24 hr. duration)

Location of centroid of basin,

$$\text{Long.} = 90^\circ 45' 09'' \quad \text{Lat.} = 38^\circ 59' 09''$$

$$PMP = 24.9'' \text{ (from Fig. 1, HMR 33)}$$

$$\text{Zone} = 7$$

- 3) Determining basin rainfall in terms of percentage of PMP Index Rainfall for various durations.
 (From Fig. 2, HMR 33)

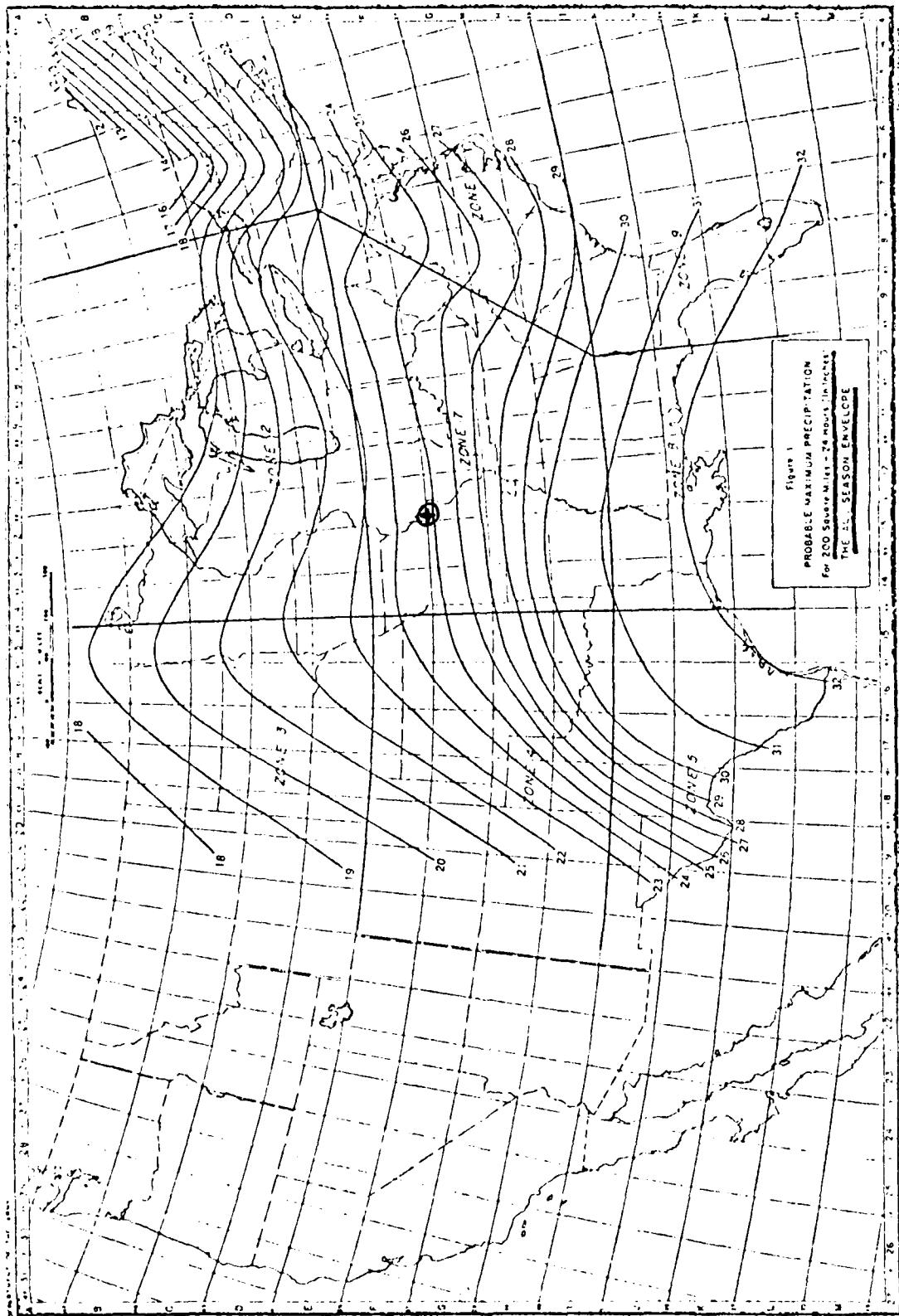
Duration (Hrs.)	Percent of Index Rainfall (%)	Total Rainfall (Inches)	Rainfall Increments (Inches)	Duration of Increment (Hrs.)
6	100	24.9	24.9	6
12	120	29.9	5.0	6
24	130	32.4	2.5	12

2083

WESTHOFF DAM
TERMINATION OF PMP

(+) LOCATION OF CENTROID OF BASIN

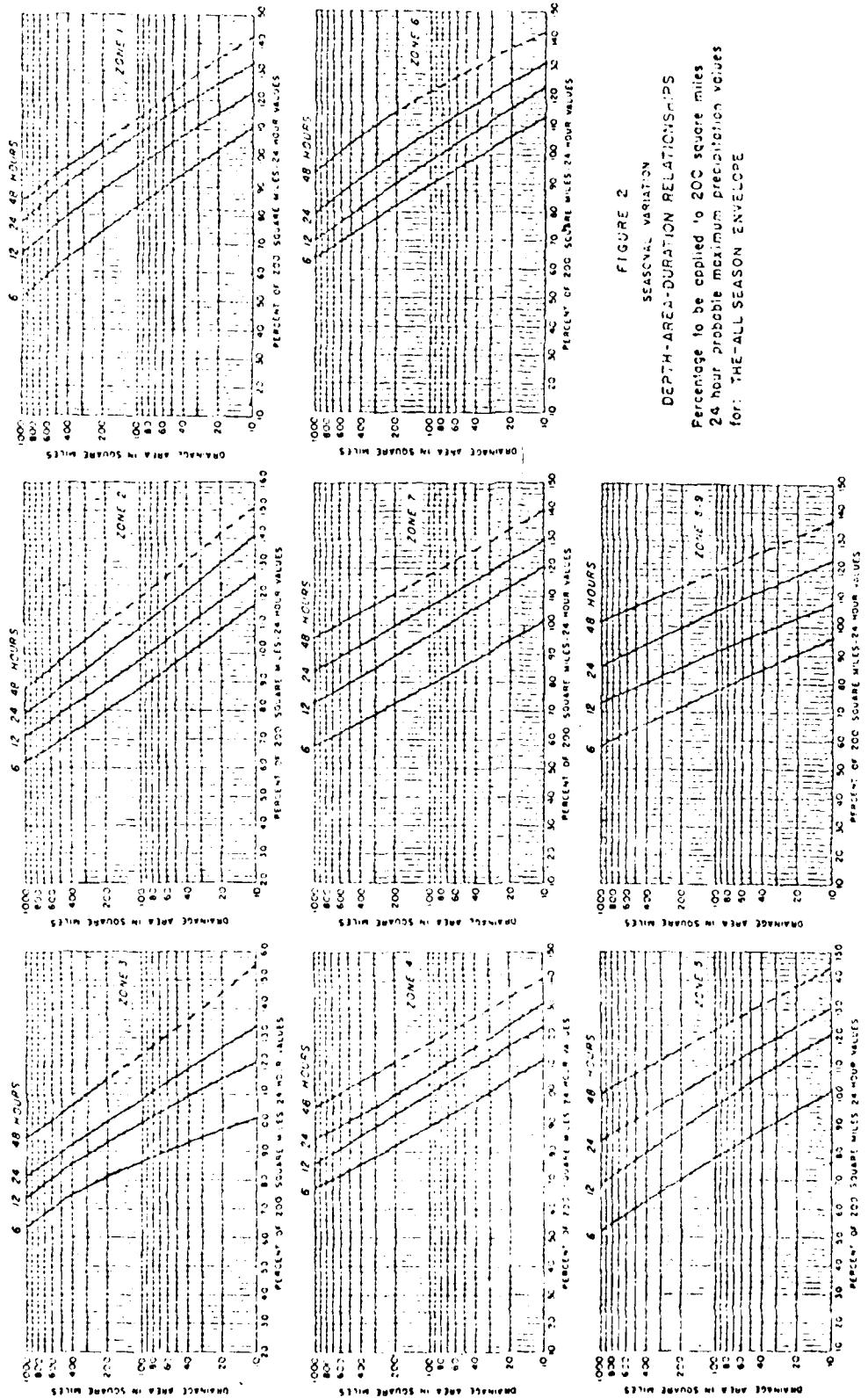
Figure 1
PROBABLE MAXIMUM PRECIPITATION
FOR 200 STORMWATER - 24 HOUR INTENSIY
THE 5% DESIGN ENVELOPE



20

B-11

3 of 3



III LUMINATING CONSULTANTS, INC.

DAM SAFETY INSPECTION / MISSOURI - 1980 SHEET NO. 1 OF 1
 DAM NAME: WESTHOFF (SMO 11140) JOB NO. 1263
 CURVE NUMBER DETERMINATION BY JFK DATE 5/15/80

I) SOIL GROUP

WATERSHED SOILS IN THE BASIN CONSIST OF GROUP A.

B

C

D

GROUP C SOILS SEEM TO PREDOMINATE THE BASIN. THEREFORE,

ASSUME GROUP C SOILS FOR THE ENTIRE WATERSHED

FOR HYDROLOGIC PURPOSES.

II) COVER COMPLEX

ASSUMED LAND USE	ASSUMED HYDROLOGIC CONDITION	PER CENT AREA	CN (AMC II)
ROW CROPS, (S.R.)	POOR	40	88
WOODS	FAIR	40	73
PASTURE OR RANGE	FAIR	20	79

III) CURVE NUMBER

WEIGHTED AVERAGE CN = 80 FOR AMC II

CURVE NUMBER = 91 FOR AMC III

PRC ENGINEERING CONSULTANTS, INC.

DAM SAFETY INSPECTION / MISSOURI

SHEET NO. 1 OF 2

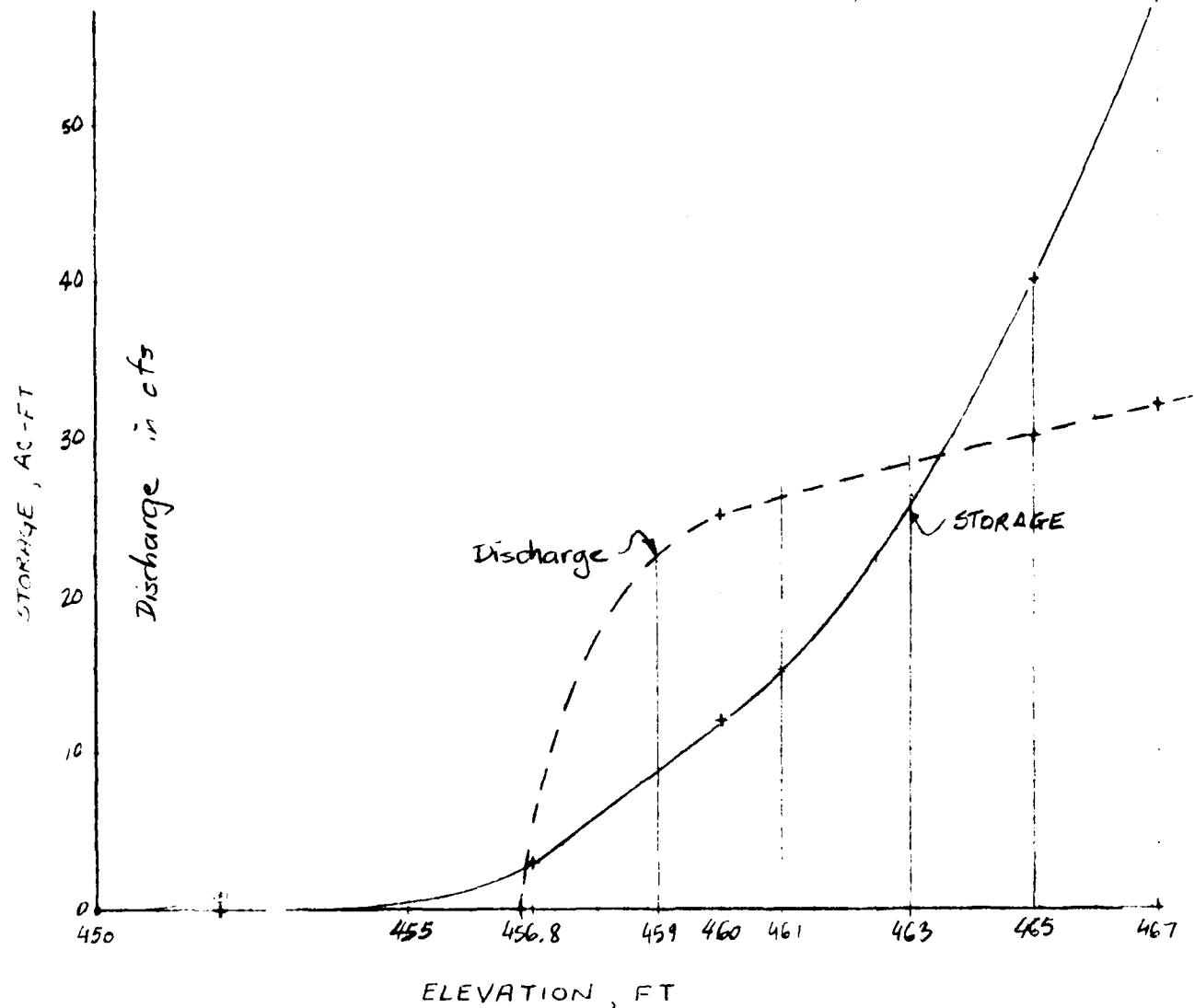
WESTHOFF LAM (MO 1140)

JOB NO. 1263

STARTING W.S. ELEVATION FOR PMF ROUTING

BY JFK DATE 5/6/80

~~RE~~ REVISED JUNE 80 /



I) WSEL = 467 at end of 1/2 PMF routing

From WSEL = 467 to 465,

$$\Delta S = 58 - 40 \text{ ac-ft} = 18 \text{ ac-ft}$$

$$\bar{Q} = 31 \text{ cfs}$$

$$\tau = 18 \text{ ac-ft} \times 43560 \frac{\text{ft}^2}{\text{ac}} \times \frac{1 \text{ s}}{31 \text{ ft}^3} \times \frac{1 \text{ day}}{86400 \text{ s}} = 0.29 \text{ days}$$

B-14

PRC ENGINEERING CONSULTANTS, INC.

DAM SAFETY INSPECTION / MISSOURI

SHEET NO. 2 OF 2

WESTHOFF DAM (MO 11140)

JOB NO 1263

STARTING W.S. EL FOR FMF ROUTING

BY JFK DATE 5/6/80

II) From WSEL 465 to 463

$$\Delta S = 40 - 26 = 14 \text{ ac-ft}$$

$$Q = 29 \text{ cfs}$$

$$t = 14 \frac{\text{ac-ft}}{\text{ac}} \times \frac{43560 \frac{\text{ft}^2}{\text{ac}}}{29 \frac{\text{ft}^3}{\text{sec}}} \times \frac{5 \text{ sec}}{\frac{\text{day}}{86400 \text{ sec}}} = 0.24 \text{ days}$$

III) From WSEL 463 to 461

$$\Delta S = 26 - 15 = 11 \text{ ac-ft}$$

$$Q = 27 \text{ cfs}$$

$$t = 11 \frac{\text{ac-ft}}{\text{ac}} \times \frac{43560 \frac{\text{ft}^2}{\text{ac}}}{27 \frac{\text{ft}^3}{\text{sec}}} \times \frac{5 \text{ sec}}{\frac{\text{day}}{86400 \text{ sec}}} = 0.21 \text{ days}$$

IV) From WSEL 461 - 459

$$\Delta S = 15 - 9 = 6 \text{ ac-ft}$$

$$Q = 25 \text{ cfs}$$

$$t = 6 \frac{\text{ac-ft}}{\text{ac}} \times \frac{43560 \frac{\text{ft}^2}{\text{ac}}}{25 \frac{\text{ft}^3}{\text{sec}}} \times \frac{5 \text{ sec}}{\frac{\text{day}}{86400 \text{ sec}}} = 0.12 \text{ day}$$

V) From WSEL 459 - 457

$$\Delta S = 9 - 3 = 6 \text{ ac-ft}$$

$$Q = 12 \text{ cfs}$$

$$t = 6 \frac{\text{ac-ft}}{\text{ac}} \times \frac{43560 \frac{\text{ft}^2}{\text{ac}}}{12 \frac{\text{ft}^3}{\text{sec}}} \times \frac{5 \text{ sec}}{\frac{\text{day}}{86400 \text{ sec}}} = 0.25 \text{ day}$$

VI) Total time required for WSEL to reach principal spillway crest

$$T = 0.29 + 0.24 + 0.21 + 0.12 + 0.25 = 1.11 \text{ day} < 3 \text{ days OK.}$$

∴ Start routing at Principal Spillway Crest Elevation

PRC ENGINEERING CONSULTANTS, INC.

DAM SAFETY INSPECTION

SHEET NO. 1 OF 1

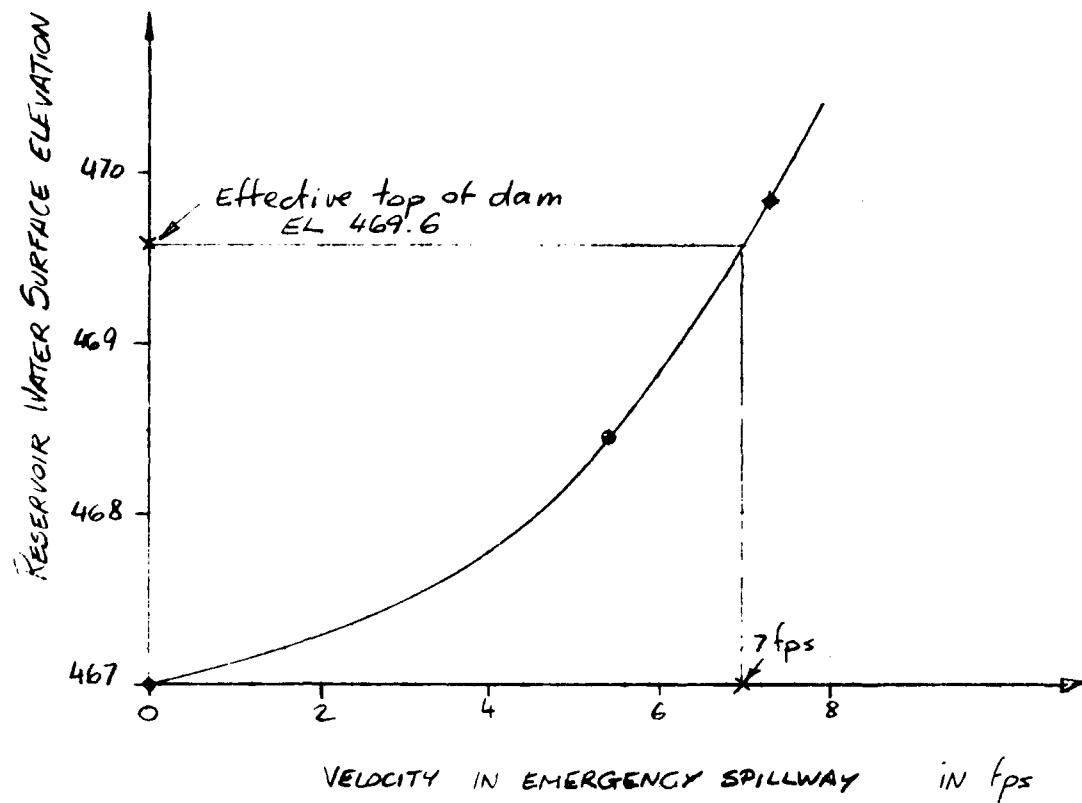
WESTHOFF DAM (MO 11140)

JOB NO. 1263

DETERMINATION OF EFFECTIVE TOP OF DAM

BY FZ

DATE June 80



Emergency Spillway Channel is a grass lined earth channel.

Assuming channel material as "KENTUCKY BLUE GRASS - SILT CLAY", the maximum permissible mean channel velocity is 7 ft/sec. (page 36 EM 1110-2-1601).

The water surface elevation in the reservoir corresponding to a velocity of 7 ft/sec in the emergency spillway is 469.6. Thus the "Effective Top of Dam" for Westhoff dam is at elevation 469.6 above M.S.L.

HEC1DB INPUT DATA

ROUTINE HYDROGRAPH PACKAGE (REC-1)
SAFETY INSPECTION JULY 1978
LADT SPECIFICATION 26 FEB 78

CIAA SAFETY INSPECTION - MISSOURI

WESTHOFF DAM (NO 1114G)

50% AND 50 PERCENT FWF

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INFLOW PMF AND ONE-HALF PMF HYDROGRAPHS

B-19

PERMITTING REQUIREMENTS OF STREAM IMPACT CALCULATIONS

BUNNELL MINE, LONGSBY, MT
0.75 MILE SOUTH OF BUNNELL,
SARITA, NEVADA

1-BLOOD HYDROGRAPHIC CHART GE (HEC-1)
1-JAH SAFETY VERSION JULY 1974
1-LAST MODIFICATION 26 FEB 74

卷之三

OPEN SAFETY IN OCTOBER - MISSOURI
OPEN SAFETY IN OCTOBER - MISSOURI
OPEN SAFETY IN OCTOBER - MISSOURI
OPEN SAFETY IN OCTOBER - MISSOURI

MULTIVARIATE ANALYSIS FOR DIFFERENTIATED MARKETING

***** UNIT HYDROGRAPH COMPUTATION *****
 INPUT PRECIPITATION NOFORCATION FOR UNIT HYDROGRAPH PARAMETERS
 TSTN1 IFC01 ITARE JPRT TAW TSTAGE TAUTO
 11140 3 0 0 0 0 0 0
 ITHDG IUNG TAREA SCAI HYDROGRAPH DATA
 1 2 0.0 1.50 0.000 0 LOCAL
 SPFT 7.0 26 1.00 1.00 0.00 0.00 0.00
 0.0 24.0 100.0 1.00 0.00 0.00 0.00 0.00
 LR0PRT STAKH ITKFL STAKH STAKH STICK STICK CNSTL CNSTL ATIMP
 1 Q.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.00
 CURVE NO = -91.00 RETAINSS = -1.00 EFFECT CH = 91.00
 UNIT HYDROGRAPH DATA
 TC = 0.00 LATE 0.0
 RECCESSION DATA
 STAY 1 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
 UNIT HYDROGRAPH 70.00 OF PTKIN ORIGINATES TCT 0.000 GUNS & AGS 0.50 VOLC 1.00
 370. 52. 25. 23. 16. 11. 10. 8. 5.
 815. 172. 250. 250. 172. 172. 172. 172. 172.

B-21

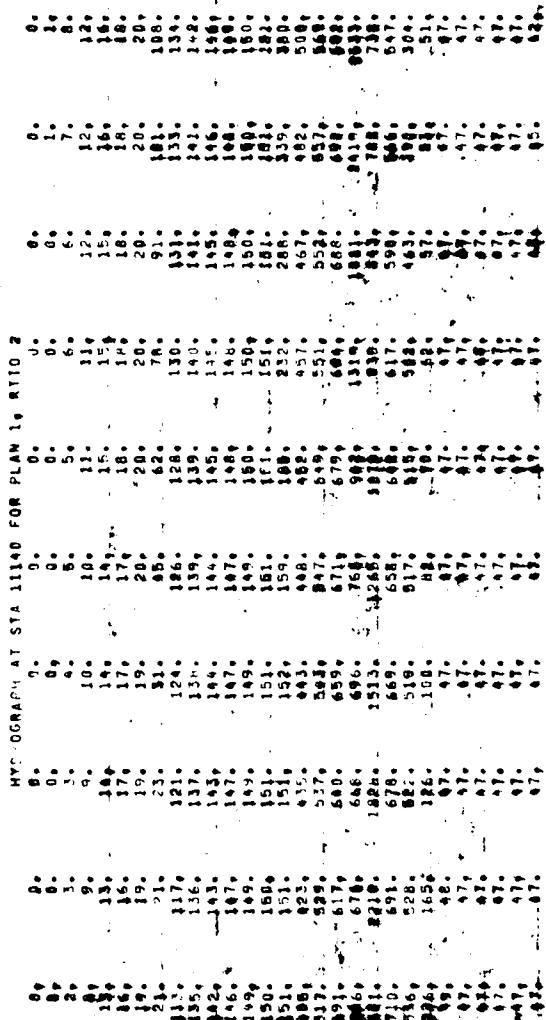
B-22

B-23

HYDROGRAPH AT STA 11140 FOP PLAN 19 APR 19

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CF.	5266.	1526.	467.	467.	14015.
CMS	140.	41.	10.	13.	3960.
INCHES	24.47	31.21	31.21	31.21	31.21
MP	679.68	792.08	792.08	792.08	792.08
AC-1	75.5	95.0	95.0	95.0	95.0
THOUS CU Y	932.	1190.	1190.	1190.	1190.

HYDROGRAPH AT STA 11140 FOR PLAN 14 RT10.2



PMF FLOOD ROUTING

B-26

	34.	35.	36.	37.	38.	39.	40.	41.	42.	43.	44.	45.	46.	47.	48.	49.	50.	51.	52.	53.	54.	55.
1-HR. CWS INCHES	26.3.	75.	76.	243.	243.	243.	243.	243.	243.	243.	243.	243.	243.	243.	243.	243.	243.	243.	243.	243.	243.	243.
MM				12.6.	12.6.	12.6.	12.6.	12.6.	12.6.	12.6.	12.6.	12.6.	12.6.	12.6.	12.6.	12.6.	12.6.	12.6.	12.6.	12.6.	12.6.	
A-CFT THOU. CU. M				10.4.	10.4.	10.4.	10.4.	10.4.	10.4.	10.4.	10.4.	10.4.	10.4.	10.4.	10.4.	10.4.	10.4.	10.4.	10.4.	10.4.	10.4.	
THOU. CU. M				378.	378.	378.	378.	378.	378.	378.	378.	378.	378.	378.	378.	378.	378.	378.	378.	378.	378.	
				462.	462.	462.	462.	462.	462.	462.	462.	462.	462.	462.	462.	462.	462.	462.	462.	462.		
				595.	595.	595.	595.	595.	595.	595.	595.	595.	595.	595.	595.	595.	595.	595.	595.	595.		

HYDROGRAPH ROUTING

ROUTE IN.F.C. HYDROGRAPH THROUGH JESTHORF DAM (INC 11140)

STATION	TC NO	PCCN	ITAPE	JPT	JRT	INAME	STAGE	IAUTO
11140	1	0	0	0	0	0	0	0
ROUTE	CLOSIS	AVG	ROUTING DATA	ROUT	TPMT	LSTA		
0.000	0.000	1	1	0	0	0		
ASTS:	ASTOL	LAG	AMSKM	X	STORA	IPRAT		
1	1	C	0.0000	0.0000	0.0000	-497.		
STAGE	475.70	460.00	465.00	470.00	468.00	469.00	473.50	474.20
PL0.	475.70	460.00	465.00	470.00	468.00	469.00	473.50	474.20
SURFACE AREA	0.	0.	0.	0.	0.	0.	0.	0.
CAPACITY	0.	0.	0.	0.	0.	0.	0.	0.
ELEVATION	462.	462.	462.	462.	462.	462.	462.	462.
CREL	SPMIC	CG34	EXPN	ELVEL	COOL	CAFEA	EMPL	
466.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
		DAM DATA						
		TOPEL	COOL	FACID	NAMEID			
		476.0	0.0	0.0				
STATION	11140.	PLAN 1.	RATIO 1					

END-OF-PERIOD HYDROGRAPH ORDINATES

	OUTFLOW																						
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	
1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.		
2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.		
3.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.		
4.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.		
5.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.		
6.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.		
7.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.		
8.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.		
9.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.		
10.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.		
11.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.		
12.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.		
13.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.		
14.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.		
15.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.		
16.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.		
17.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.		
18.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.		

	OUTFLOW																						
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.		
1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.		
2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.		
3.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.		
4.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.		
5.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.		
6.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.		
7.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.		
8.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.		
9.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.		
10.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.		
11.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.		
12.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.		
13.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.		
14.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.		
15.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.		
16.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.		
17.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.		
18.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.		

B-27

#3-283

STATION 111400 PLAN 10 HATIO 2
END-OF-PERIOD HYDROCEPHALUS ORNIVATES

AD-A106 512 PRC CONSOER TOWNSEND INC ST LOUIS MO
NATIONAL DAM SAFETY PROGRAM. WESTHOFF DAM (MO 11140), MISSISSIPPI--ETC(U)
SEP 80 W G SHIFRIN DACW43-80-C-0094
UNCLASSIFIED NL

2 02
2
2000AC
2000AC

END
DATE FILMED
12-81
DTIC

ONE-HALF PMF FLOOD ROUTING

B-30

STAN SOUTHERN 15 2311 11 TIME 15.92 HIGHPS

	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CER-	253.0	736.	216.	6216.1
COS	72.	21.	6.	1760.4
4-CHLORO-				13.5
PW	293.15	351.71	351.71	351.71
AC-IT				428.
TMICLICUM	44.0	56.9	52.6	428.
				528.

	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CER-	253.0	736.	216.	6216.1
COS	72.	21.	6.	1760.4
4-CHLORO-				13.5
PW	293.15	351.71	351.71	351.71
AC-IT				428.
TMICLICUM	44.0	56.9	52.6	428.
				528.

SUMMARY OF PMF AND ONE-HALF PMF FLOOD ROUTING

B-33

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS	
				RATIO 1	RATIO 2
HYDROGRAPH AT	11160	.954	1	5266.	2633.
ROUTE FG	11160	1.500	1	14.03334	74.5714
				515.6.	251.
				146.02114	71.6614

SUMMARY OF DAM SAFETY ANALYSIS

PLAN	ELFTATION STORAGE OUTLET	INITIAL VAIUE	SPILLWAY CEF. I	TOP OF DAM
1	45.0	456.00	475.00	95.00
	3.	3.	3.	95.
	0.	0.	0.	92.
RATIO OF RESERVA- TORY to SOLI- TY	MATERIAL TYPE OF DAM	MAXIMUM STORAG- E CAP-	MAXIMUM OUTLEAD CFS	DURATION OVER TOP HOURS
1.00	971.5%	1.5%	120.	5156.
.90	470.0%	.83	106.	7531.
				1.00
				15.92
				0.00
				3.00

B-35

PERCENT OF PMF FLOOD ROUTING
EQUAL TO SPILLWAY CAPACITY

FLOOD HYDROGRAPH FACTAGE (THE C-1)
DAM SAFETY VER-SIGN JULY 1976
LAST MODIFICATION 26 FEB 73

240 SAFETY INSPECTION - MISSOURI WESTHOFF DAM (MO 1114C)									
PERCENT PMF									
1	1	300	0	5	0	C	0	-4	1
2	2	1	5	1	1				
3	3	•1	1	•17	•18	•22			
4	4	•1	1	1114C		0			
5	5	•1	1	•12	•13				
6	6	•1	1	1114C					
7	7	•1	1	1114C					
8	8	•1	1	1114C					
9	9	•1	1	1114C					
10	10	•1	1	1114C					
11	11	•1	1	1114C					
12	12	•1	1	1114C					
13	13	•1	1	1114C					
14	14	•1	1	1114C					
15	15	•1	1	1114C					
16	16	•1	1	1114C					
17	17	•1	1	1114C					
18	18	1	1	462	465	467	468•5	469•5	470•5
19	19	1	1	462	465	467	468•5	469•5	470•5
20	20	1	1	475•7	475•7	475•7	475•7	475•7	475•7
21	21	1	1	475•7	475•7	475•7	475•7	475•7	475•7
22	22	1	1	475•7	475•7	475•7	475•7	475•7	475•7
23	23	1	1	475•7	475•7	475•7	475•7	475•7	475•7
24	24	1	1	475•7	475•7	475•7	475•7	475•7	475•7
25	25	1	1	475•7	475•7	475•7	475•7	475•7	475•7
26	26	1	1	475•7	475•7	475•7	475•7	475•7	475•7
27	27	1	1	475•7	475•7	475•7	475•7	475•7	475•7

B-37

PREVIEWS OF EQUATIONS OF STREAM NETWORK CALCULATIONS

NUMBER HYDROGRAPH 21
ROUTE NUMBER 10
DATE OF RECORD 7/1
DATE OF ACTUAL 7/1

B-38

BLOCC HYDROGRAPH PACKAGE (BFC-1)
DATA SAFETY VERSION 1.0 JULY 1-76
LAST MODIFICATION 2.0 FEB 76

RUN DATE: 5/26/76/C
TIME: 07:36:07.

DEA STATION INJECTION = WATERSHED
WEATHER DATA (MC 11140)
PRACET1.PMF

NO	NBR	NAME	TYPE	JOI	IMP	JOI SPECIFICATION	INFLT	IPRT	NSIM
1.0			JOI	0	0	METRIC	0	-4	0
			JFTR	0	0	NET	0	0	0
				0	0	TRACT	0	0	0
					0		0	0	0

MULTI-PLAN ANALYSIS TO BE PERFORMED
PLAN = 1 WRITE = 0 LPT1 = 1
RATIO = .13 .17 .11 .02

***** RUNOFF COMPUTATION *****

WELL PRECIPITATION INfiltrations AND UNIT HYDROGRAPH PARAMETERS

STAG	ICOMP	ICOF	ITARE	JLT	JPNT	INAME	ISAGE	IAUTO
11140	0	0	0	0	0	0	0	0

HYDS	INFS	PARA	CNAME	HYDROS-AWD DATA	RATIO	IS:0:0	ISAME	LOCAL
1		0.00	0.00	0.00	0.00	0	1	0
				0.00	0.00			
				0.00	0.00			
				0.00	0.00			

SPECIAL DATA
SPF = PMS R6 100.00 120.00 100.00 0.00 R48 R72 R96
0.00 24.90 100.00 120.00 100.00 0.00 0.00 0.00

CURVE NO = -91.30 MFTNESS = -1.00 EFFECT CN = 41.00

UNIT HYDROGRAPH DATA
IC = 0.00 LAT = .30

REGRESSION DATA
STRTG = 0.00 QRCST = 0.00 KTRDR = 1.00

END-OF-PERIOD FLUX
NO.DN PERIOD RAIN FACS LOSS COMP MODA HS.MN PERIOD RAIN FACS LOSS COND C

B-39

SUM 32.37 51.21 1.16 140111.
(87.0 (793.0 (29.0 (3967.50)

HYDROGRAPHIC WORKING

ROUTE INTL - HYDROGRAPHIC WORKING (11140)

STATION	ICOMP	RECON	STATE	JETT	DEW	INAMI	STAGE	TAUJO
1114	1	1	FCUTLINE DATA	0	0	0	0	0
QLS55	CLOSS	LVS	FCUTLINE ISMAP	1.00	1.00	1.00	1.00	1.00
3.0.0	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
NETIC	SYOL	LAG	AVERAGE	X	X	X	X	X
0	0	0	0.00	0.00	0.00	0.00	-1	-1
STAGE	456.0	446.0	447.0	447.0	447.0	447.0	473.50	473.50
PLC6	25939.0	25.00	25.00	22.00	22.00	22.00	15.98	15.98
SURFACE AREA=	0.	0.	0.	0.	0.	0.	0.	0.
CAPACITY=	0.	0.	0.	0.	0.	0.	0.	0.
ELEVATION=	457.0	457.0	457.0	457.0	457.0	457.0	457.0	457.0
PEAK	457.0	457.0	457.0	457.0	457.0	457.0	457.0	457.0
TOPLL	457.0	457.0	457.0	457.0	457.0	457.0	457.0	457.0
DEW	457.0	457.0	457.0	457.0	457.0	457.0	457.0	457.0
INAMI	457.0	457.0	457.0	457.0	457.0	457.0	457.0	457.0
TAUJO	457.0	457.0	457.0	457.0	457.0	457.0	457.0	457.0

PEAK CUTOFF IS 1580 AT TIME 16.02H JUO-5

PEAK OUTFLOWS 4520 AT TIME 16.02H JUO-5

PEAK CUTOFF IS 5070 AT TIME 16.017 HOU 5

MEAN OUTFLOW IS 8990 AT TIME 16.017 HOU 5

Reportage

B-40

PEAK FLUX AND STORM (T₁) IN PREDICTED DOWNTOWNSHIP AND MULTIPLE PLANE-RATIO FLOODICIC COMPUTATIONS
 FOR THE 100-YEAR FLOOD (CULVERT, WETLAND, DRY STREAM)
 APRIL 1970, CLEVELAND, OHIO (R-1)

STATISTICS		PEAK		PEAK		STATISTICS	
STATION	AREA	STATION	AREA	STATION	AREA	STATION	AREA
100-100-111%		100-100-111%		100-100-111%		100-100-111%	
EV. 1.4400000000000001	1.0000000000000001						
EV. 1.4400000000000001	1.0000000000000001						
EV. 1.4400000000000001	1.0000000000000001						

SUMMARY OF DAM SAFETY ANALYSIS

PLAN	ELEVATION OF TOP OF DAM AND OVERFALL STORAGE CAPACITY	INITIAL LEVEL OF OVERFALL STORAGE CAPACITY	SPILLWAY CAPACITY CFS	TIME OF SPILLWAY OPENING HRS	TIME OF OUTFLOW FROM CEP HRS	DURATION OF OVERFALL STORAGE CAPACITY HRS	TIME OF OUTFLOW FROM CEP HRS	TIME OF OVERFALL STORAGE CAPACITY HRS	TIME OF OUTFLOW FROM CEP HRS	TIME OF OVERFALL STORAGE CAPACITY HRS
1	100.00	100.00	1000	0.00	0.00	0.00	0.00	100.00	0.00	100.00
	99.95	99.95	1000	0.00	0.00	0.00	0.00	99.95	0.00	99.95
	99.90	99.90	1000	0.00	0.00	0.00	0.00	99.90	0.00	99.90
	99.85	99.85	1000	0.00	0.00	0.00	0.00	99.85	0.00	99.85
	99.80	99.80	1000	0.00	0.00	0.00	0.00	99.80	0.00	99.80
	99.75	99.75	1000	0.00	0.00	0.00	0.00	99.75	0.00	99.75
	99.70	99.70	1000	0.00	0.00	0.00	0.00	99.70	0.00	99.70
	99.65	99.65	1000	0.00	0.00	0.00	0.00	99.65	0.00	99.65
	99.60	99.60	1000	0.00	0.00	0.00	0.00	99.60	0.00	99.60
	99.55	99.55	1000	0.00	0.00	0.00	0.00	99.55	0.00	99.55
	99.50	99.50	1000	0.00	0.00	0.00	0.00	99.50	0.00	99.50
	99.45	99.45	1000	0.00	0.00	0.00	0.00	99.45	0.00	99.45
	99.40	99.40	1000	0.00	0.00	0.00	0.00	99.40	0.00	99.40
	99.35	99.35	1000	0.00	0.00	0.00	0.00	99.35	0.00	99.35
	99.30	99.30	1000	0.00	0.00	0.00	0.00	99.30	0.00	99.30
	99.25	99.25	1000	0.00	0.00	0.00	0.00	99.25	0.00	99.25
	99.20	99.20	1000	0.00	0.00	0.00	0.00	99.20	0.00	99.20
	99.15	99.15	1000	0.00	0.00	0.00	0.00	99.15	0.00	99.15
	99.10	99.10	1000	0.00	0.00	0.00	0.00	99.10	0.00	99.10
	99.05	99.05	1000	0.00	0.00	0.00	0.00	99.05	0.00	99.05
	99.00	99.00	1000	0.00	0.00	0.00	0.00	99.00	0.00	99.00
	98.95	98.95	1000	0.00	0.00	0.00	0.00	98.95	0.00	98.95
	98.90	98.90	1000	0.00	0.00	0.00	0.00	98.90	0.00	98.90
	98.85	98.85	1000	0.00	0.00	0.00	0.00	98.85	0.00	98.85
	98.80	98.80	1000	0.00	0.00	0.00	0.00	98.80	0.00	98.80
	98.75	98.75	1000	0.00	0.00	0.00	0.00	98.75	0.00	98.75
	98.70	98.70	1000	0.00	0.00	0.00	0.00	98.70	0.00	98.70
	98.65	98.65	1000	0.00	0.00	0.00	0.00	98.65	0.00	98.65
	98.60	98.60	1000	0.00	0.00	0.00	0.00	98.60	0.00	98.60
	98.55	98.55	1000	0.00	0.00	0.00	0.00	98.55	0.00	98.55
	98.50	98.50	1000	0.00	0.00	0.00	0.00	98.50	0.00	98.50
	98.45	98.45	1000	0.00	0.00	0.00	0.00	98.45	0.00	98.45
	98.40	98.40	1000	0.00	0.00	0.00	0.00	98.40	0.00	98.40
	98.35	98.35	1000	0.00	0.00	0.00	0.00	98.35	0.00	98.35
	98.30	98.30	1000	0.00	0.00	0.00	0.00	98.30	0.00	98.30
	98.25	98.25	1000	0.00	0.00	0.00	0.00	98.25	0.00	98.25
	98.20	98.20	1000	0.00	0.00	0.00	0.00	98.20	0.00	98.20
	98.15	98.15	1000	0.00	0.00	0.00	0.00	98.15	0.00	98.15
	98.10	98.10	1000	0.00	0.00	0.00	0.00	98.10	0.00	98.10
	98.05	98.05	1000	0.00	0.00	0.00	0.00	98.05	0.00	98.05
	98.00	98.00	1000	0.00	0.00	0.00	0.00	98.00	0.00	98.00
	97.95	97.95	1000	0.00	0.00	0.00	0.00	97.95	0.00	97.95
	97.90	97.90	1000	0.00	0.00	0.00	0.00	97.90	0.00	97.90
	97.85	97.85	1000	0.00	0.00	0.00	0.00	97.85	0.00	97.85
	97.80	97.80	1000	0.00	0.00	0.00	0.00	97.80	0.00	97.80
	97.75	97.75	1000	0.00	0.00	0.00	0.00	97.75	0.00	97.75
	97.70	97.70	1000	0.00	0.00	0.00	0.00	97.70	0.00	97.70
	97.65	97.65	1000	0.00	0.00	0.00	0.00	97.65	0.00	97.65
	97.60	97.60	1000	0.00	0.00	0.00	0.00	97.60	0.00	97.60
	97.55	97.55	1000	0.00	0.00	0.00	0.00	97.55	0.00	97.55
	97.50	97.50	1000	0.00	0.00	0.00	0.00	97.50	0.00	97.50
	97.45	97.45	1000	0.00	0.00	0.00	0.00	97.45	0.00	97.45
	97.40	97.40	1000	0.00	0.00	0.00	0.00	97.40	0.00	97.40
	97.35	97.35	1000	0.00	0.00	0.00	0.00	97.35	0.00	97.35
	97.30	97.30	1000	0.00	0.00	0.00	0.00	97.30	0.00	97.30
	97.25	97.25	1000	0.00	0.00	0.00	0.00	97.25	0.00	97.25
	97.20	97.20	1000	0.00	0.00	0.00	0.00	97.20	0.00	97.20
	97.15	97.15	1000	0.00	0.00	0.00	0.00	97.15	0.00	97.15
	97.10	97.10	1000	0.00	0.00	0.00	0.00	97.10	0.00	97.10
	97.05	97.05	1000	0.00	0.00	0.00	0.00	97.05	0.00	97.05
	97.00	97.00	1000	0.00	0.00	0.00	0.00	97.00	0.00	97.00
	96.95	96.95	1000	0.00	0.00	0.00	0.00	96.95	0.00	96.95
	96.90	96.90	1000	0.00	0.00	0.00	0.00	96.90	0.00	96.90
	96.85	96.85	1000	0.00	0.00	0.00	0.00	96.85	0.00	96.85
	96.80	96.80	1000	0.00	0.00	0.00	0.00	96.80	0.00	96.80
	96.75	96.75	1000	0.00	0.00	0.00	0.00	96.75	0.00	96.75
	96.70	96.70	1000	0.00	0.00	0.00	0.00	96.70	0.00	96.70
	96.65	96.65	1000	0.00	0.00	0.00	0.00	96.65	0.00	96.65
	96.60	96.60	1000	0.00	0.00	0.00	0.00	96.60	0.00	96.60
	96.55	96.55	1000	0.00	0.00	0.00	0.00	96.55	0.00	96.55
	96.50	96.50	1000	0.00	0.00	0.00	0.00	96.50	0.00	96.50
	96.45	96.45	1000	0.00	0.00	0.00	0.00	96.45	0.00	96.45
	96.40	96.40	1000	0.00	0.00	0.00	0.00	96.40	0.00	96.40
	96.35	96.35	1000	0.00	0.00	0.00	0.00	96.35	0.00	96.35
	96.30	96.30	1000	0.00	0.00	0.00	0.00	96.30	0.00	96.30
	96.25	96.25	1000	0.00	0.00	0.00	0.00	96.25	0.00	96.25
	96.20	96.20	1000	0.00	0.00	0.00	0.00	96.20	0.00	96.20
	96.15	96.15	1000	0.00	0.00	0.00	0.00	96.15	0.00	96.15
	96.10	96.10	1000	0.00	0.00	0.00	0.00	96.10	0.00	96.10
	96.05	96.05	1000	0.00	0.00	0.00	0.00	96.05	0.00	96.05
	96.00	96.00	1000	0.00	0.00	0.00	0.00	96.00	0.00	96.00
	95.95	95.95	1000	0.00	0.00	0.00	0.00	95.95	0.00	95.95
	95.90	95.90	1000	0.00	0.00	0.00	0.00	95.90	0.00	95.90
	95.85	95.85	1000	0.00	0.00	0.00	0.00	95.85	0.00	95.85
	95.80	95.80	1000	0.00	0.00	0.00	0.00	95.80	0.00	95.80
	95.75	95.75	1000	0.00	0.00	0.00	0.00	95.75	0.00	95.75
	95.70	95.70	1000	0.00	0.00	0.00	0.00	95.70	0.00	95.70
	95.65	95.65	1000	0.00	0.00	0.00	0.00	95.65	0.00	95.65
	95.60	95.60	1000	0.00	0.00	0.00	0.00	95.60	0.00	95.60
	95.55	95.55	1000	0.00	0.00	0.00	0.00	95.55	0.00	95.55
	95.50	95.50	1000	0.00	0.00	0.00	0.00	95.50	0.00	95.50
	95.45	95.45	1000	0.00	0.00	0.00	0.00	95.45	0.00	95.45
	95.40	95.40	1000	0.00	0.00	0.00	0.00	95.40	0.00	95.40
	95.35	95.35	1000	0.00	0.00	0.00	0.00	95.35	0.00	95.35
	95.30	95.30	1000	0.00	0.00	0.00	0.00	95.30	0.00	95.30
	95.25	95.25	1000	0.00	0.00	0.00	0.00	95.25	0.00	95.25
	95.20	95.20	1000	0.00	0.00	0.00	0.00	95.20	0.00	95.20
	95.15	95.15	1000	0.00	0.00	0.00	0.00	95.15	0.00	95.15
	95.10	95.10	1000	0.00	0.00	0.00	0.00	95.10	0.00	95.10
	95.05	95.05	1000	0.00	0.00	0.0				

END
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